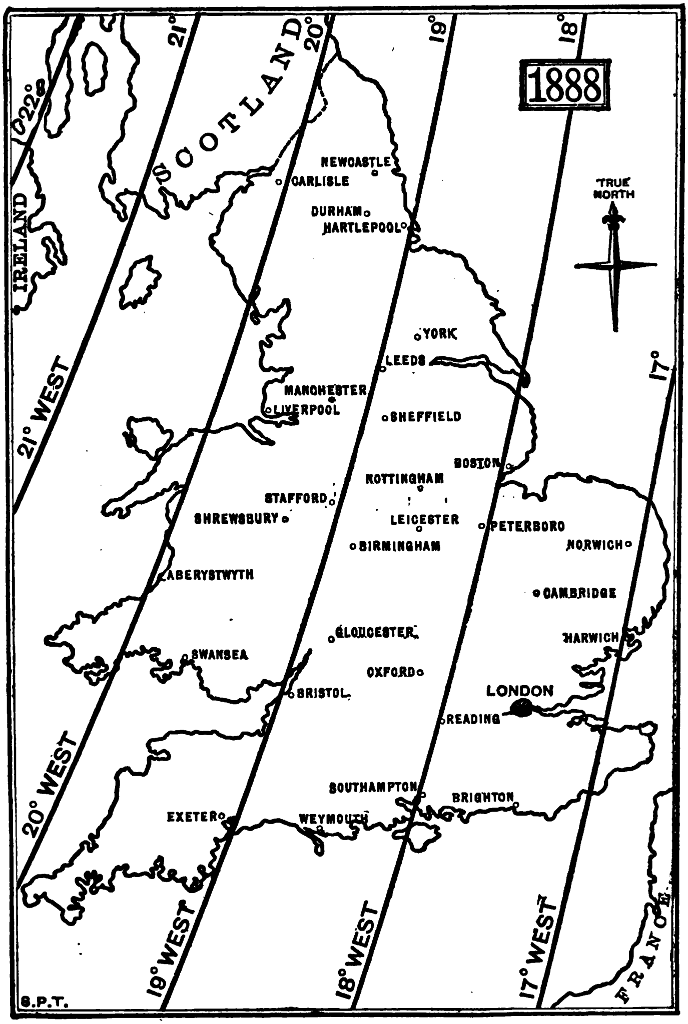
NUMERICAL TABLES AND CONSTANTS

IN

ELEMENTARY SCIENCE.



Map of England, showing Lines of Equal Magnetic Declination for the Year 1888.

From *Electricity and Magnetism*, Prof. S. P. Thompson.

NUMERICAL TABLES AND CONSTANTS

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BY

SYDNEY LUPTON, M.A., F.C.S., F.I.C.

ASSISTANT MASTER AT HARROW SCHOOL.

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PREFACE.

THE following collection of Tables in the more elementary portions of Natural Science is intended to supplement the ordinary text-books, and to assist learners, teachers, and those engaged in Laboratory work. By the use of such a book those learners who depend solely upon oral instruction may be saved the trouble of copying down long lists of figures, and others may frequently find data additional or external to those given in their text-books. To teachers, who have to turn rapidly from one branch of science to another, the tables will, I hope, be convenient in the construction of numerical problems, which so powerfully assist in fixing and rendering clear the ideas gained from lectures or text-books, and will serve to remind them of a forgotten number without an irritating search through bulky manuals. Persons engaged in practical work will find the book useful both as a compendium of numerical facts outside their particular branch of study, and as an aid in working out the results of their own experiments.

In preparing a work, however elementary, of so wide a scope as this, an author must depend much on the kind assistance of those specially cognisant of the various branches of which

he treats, and on the labours of previous writers. In the former category my special thanks are due to Professors REINOLD and SILVANUS THOMPSON, for valuable assistance in the section on Electricity; to WILLIAM ELLIS, Esq., for some Tables in Terrestrial Magnetism; and to H. J. CHANEY, Esq., for much help in the difficult subject of the English and Metric Measures. I am also most grateful to my friend and former colleague, DONALD MACALISTER, Esq., who has kindly read both the MS. and the proof, numerous corrections and suggestions in which are due to his accurate knowledge and sound judgment.

The following list of authorities, to whom I am more particularly indebted, will serve both as an acknowledgment of my obligation, and as a guide to those who desire further information than could be compressed into the limited space at my disposal.

S. L.

HARROW,
March 1884.

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ELEMENTARY SCIENCE.

CHEMISTRY.

PHYSIOGRAPHY.

NUMERICAL TABLES AND CONSTANTS

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ELEMENTARY SCIENCE.

NUMBERS AND MEASURES.

(1) Squares, Cubes, Square and Cube Roots, Reciprocals.

n	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	$n\pi$	$\frac{1}{n}$
2	4	8	1·414	1·260	6·28	50000
3	9	27	1·732	1·442	9·42	33333
4	16	64	2·000	1·587	12·57	25000
5	25	125	2·236	1·710	15·71	20000
6	36	216	2·449	1·817	18·85	16667
7	49	343	2·646	1·913	21·99	14286
8	64	512	2·828	2·000	25·13	12500
9	81	729	3·000	2·080	28·27	11111
10	100	1000	3·162	2·154	31·42	10000
11	121	1331	3·317	2·224	34·56	90909
12	144	1728	3·464	2·289	37·70	83333
13	169	2197	3·606	2·351	40·84	76923
14	196	2744	3·742	2·410	43·98	71429
15	225	3375	3·873	2·466	47·12	66667
16	256	4096	4·000	2·520	50·27	62500
17	289	4913	4·123	2·571	53·41	58824
18	324	5832	4·243	2·621	56·55	55556
19	361	6859	4·359	2·668	59·69	52632
20	400	8000	4·472	2·714	62·83	50000
21	441	9261	4·583	2·759	65·97	47619
22	484	10648	4·690	2·802	69·11	45455
23	529	12167	4·796	2·844	72·26	43478

n	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	$n\pi$	$\frac{1}{n}$
24	576	13824	4·899	2·884	75·40	41667
25	625	15625	5·000	2·924	78·54	40000
26	676	17576	5·099	2·962	81·68	38462
27	729	19683	5·196	3·000	84·82	37037
28	784	21952	5·291	3·037	87·96	35714
29	841	24389	5·385	3·072	91·11	34483
30	900	27000	5·477	3·107	94·25	33333
31	961	29791	5·568	3·141	97·39	32258
32	1024	32768	5·657	3·175	100·53	31250
33	1089	35937	5·745	3·208	103·67	30303
34	1156	39304	5·831	3·240	106·81	29412
35	1225	42875	5·916	3·271	109·96	28571
36	1296	46656	6·000	3·302	113·10	27778
37	1369	50653	6·083	3·332	116·24	27027
38	1444	54872	6·164	3·362	119·38	26316
39	1521	59319	6·245	3·391	122·52	25641
40	1600	64000	6·325	3·420	125·66	25000
41	1681	68921	6·403	3·448	128·81	24390
42	1764	74088	6·481	3·476	131·95	23810
43	1849	79507	6·557	3·503	135·09	23256
44	1936	85184	6·633	3·530	138·23	22727
45	2025	91125	6·708	3·557	141·37	22222
46	2116	97336	6·782	3·583	144·51	21739
47	2209	103823	6·856	3·609	147·65	21277
48	2304	110592	6·928	3·634	150·80	20833
49	2401	117649	7·000	3·659	153·94	20408
50	2500	125000	7·071	3·684	157·08	20000
51	2601	132651	7·141	3·708	160·22	19608
52	2704	140608	7·211	3·733	163·36	19231
53	2809	148877	7·280	3·756	166·50	18868
54	2916	157464	7·348	3·780	169·65	18519
55	3025	166375	7·416	3·803	172·79	18182
56	3136	175616	7·483	3·826	175·93	17857
57	3249	185193	7·550	3·849	179·07	17544
58	3364	195112	7·616	3·871	182·21	17241
59	3481	205379	7·681	3·893	185·35	16949
60	3600	216000	7·746	3·915	188·50	16667
61	3721	226981	7·810	3·936	191·64	16393
62	3844	238328	7·874	3·958	194·78	16129
63	3969	250047	7·937	3·979	197·92	15873
64	4096	262144	8·000	4·000	201·06	15625

n	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	$n\pi$	$\frac{1}{n}$
65	4225	274625	8·062	4·021	204·20	15385
66	4356	287496	8·124	4·041	207·34	15152
67	4489	300763	8·185	4·062	210·49	14925
68	4624	314432	8·246	4·082	213·63	14706
69	4761	328509	8·307	4·102	216·77	14493
70	4900	343000	8·367	4·121	219·91	14286
71	5041	357911	8·426	4·141	223·05	14084
72	5184	373248	8·485	4·160	226·19	13889
73	5329	389017	8·544	4·179	229·34	13699
74	5476	405224	8·602	4·198	232·48	13514
75	5625	421875	8·660	4·217	235·62	13333
76	5776	438976	8·718	4·236	238·76	13158
77	5929	456533	8·775	4·254	241·90	12987
78	6084	474552	8·832	4·273	245·04	12821
79	6241	493039	8·888	4·291	248·19	12658
80	6400	512000	8·944	4·309	251·33	12500
81	6561	531441	9·000	4·327	254·47	12346
82	6724	551368	9·055	4·344	257·61	12195
83	6889	571787	9·110	4·362	260·75	12048
84	7056	592704	9·165	4·380	263·89	11905
85	7225	614125	9·220	4·397	267·03	11765
86	7396	636056	9·274	4·414	270·18	11628
87	7569	658503	9·327	4·431	273·32	11494
88	7744	681472	9·381	4·448	276·46	11364
89	7921	704969	9·434	4·465	279·60	11236
90	8100	729000	9·487	4·481	282·74	11111
91	8281	753571	9·539	4·498	285·88	10989
92	8464	778688	9·592	4·514	289·03	10870
93	8649	804357	9·644	4·531	292·17	10753
94	8836	830584	9·695	4·547	295·31	10638
95	9025	857375	9·747	4·563	298·45	10526
96	9216	884736	9·798	4·579	301·59	10417
97	9409	912673	9·849	4·595	304·73	10309
98	9604	941192	9·899	4·610	307·88	10204
99	9801	970299	9·950	4·626	311·02	10101
			$\sqrt[3]{100} =$	4·642		

(2) Trigonometrical Ratios.

degs.	sin.	cos.	tan.	cot.	sec.	cosec.	degs.
0°	0	1	0	∞	1	∞	90°
1	·0175	·9999	·0175	57·29	1·000	57·30	89
2	·0349	·9994	·0349	28·64	1·001	28·65	88
3	·0523	·9986	·0524	19·08	1·001	19·11	87
4	·0698	·9976	·0699	14·30	1·002	14·34	86
5	·0872	·9962	·0875	11·43	1·004	11·47	85
6	·1045	·9945	·1051	9·514	1·006	9·567	84
7	·1219	·9926	·1228	8·144	1·008	8·206	83
8	·1392	·9903	·1405	7·115	1·010	7·185	82
9	·1564	·9877	·1584	6·314	1·012	6·392	81
10	·1737	·9848	·1763	5·671	1·015	5·759	80
11	·1908	·9816	·1944	5·145	1·019	5·241	79
12	·2079	·9782	·2126	4·705	1·022	4·810	78
13	·2250	·9744	·2309	4·331	1·026	4·445	77
14	·2419	·9703	·2493	4·011	1·031	4·134	76
15	·2588	·9659	·2680	3·732	1·035	3·864	75
16	·2756	·9613	·2868	3·487	1·040	3·628	74
17	·2924	·9563	·3057	3·271	1·046	3·420	73
18	·3090	·9511	·3249	3·078	1·051	3·236	72
19	·3256	·9455	·3443	2·904	1·058	3·072	71
20	·3420	·9397	·3640	2·747	1·064	2·924	70
21	·3584	·9336	·3839	2·605	1·071	2·790	69
22	·3746	·9272	·4040	2·475	1·079	2·669	68
23	·3907	·9205	·4245	2·356	1·086	2·559	67
24	·4067	·9136	·4452	2·246	1·095	2·459	66
25	·4226	·9063	·4663	2·145	1·103	2·366	65
26	·4384	·8988	·4877	2·050	1·113	2·281	64
27	·4540	·8910	·5095	1·963	1·122	2·203	63
28	·4695	·8830	·5317	1·881	1·133	2·130	62
29	·4848	·8746	·5543	1·804	1·143	2·063	61
30	·5000	·8660	·5774	1·732	1·155	2·000	60
31	·5150	·8572	·6009	1·664	1·167	1·942	59
32	·5299	·8481	·6249	1·600	1·179	1·887	58
33	·5446	·8387	·6494	1·540	1·192	1·836	57
34	·5592	·8290	·6745	1·483	1·206	1·788	56
35	·5736	·8192	·7002	1·428	1·221	1·743	55
36°	·5878	·8090	·7265	1·376	1·236	1·701	54°
degs.	cos.	sin.	cot.	tan.	cosec.	sec.	degs.

degs.	sin.	cos.	tan.	cot.	sec.	cosec.	degs.
37°	·6018	·7986	·7536	1·327	1·252	1·662	53°
38	·6157	·7880	·7813	1·280	1·269	1·624	52
39	·6293	·7772	·8098	1·235	1·287	1·589	51
40	·6428	·7660	·8391	1·192	1·305	1·556	50
41	·6561	·7547	·8693	1·150	1·325	1·524	49
42	·6691	·7431	·9004	1·111	1·346	1·494	48
43	·6820	·7314	·9325	1·072	1·367	1·466	47
44	·6947	·7193	·9657	1·036	1·390	1·440	46
45°	·7071	·7071	1·0000	1·0000	1·414	1·414	45°
degs.	cos.	sin.	cot.	tan.	cosec.	sec.	degs.

(3) Factorials, and Powers of 2.

n	$n!$	2^n
2	2	4
3	6	8
4	24	16
5	120	32
6	720	64
7	5 040	128
8	40 320	256
9	362 880	512
10	3 628 800	1024
11	39 916 800	2048
12	479 001 600	4096

(4) Logarithms of Factorials.

n	$\log n!$	n	$\log n!$	n	$\log n!$
10	6·55976303	40	47·91164507	70	100·07840504
11	7·60115572	41	49·52442892	71	101·92966338
12	8·68033696	42	51·14767822	72	103·78699588
13	9·79428032	43	52·78114667	73	105·65031874
14	10·94040835	44	54·42459935	74	107·51955046
15	12·11649961	45	56·07781186	75	109·39461172
16	13·32061959	46	57·74056969	76	111·27542532
17	14·55106852	47	59·41266755	77	113·16191604
18	15·80634102	48	61·09390879	78	115·05401064
19	17·08509462	49	62·78410487	79	116·95163774
20	18·38612462	50	64·48307487	80	118·85472772
21	19·70834391	51	66·19064505	81	120·76321274
22	21·05076659	52	67·90664839	82	122·67702659
23	22·41249443	53	69·63092426	83	124·59610469
24	23·79270567	54	71·36331802	84	126·52038397
25	25·19064568	55	73·10368071	85	128·44980290
26	26·60561903	56	74·85186874	86	130·38430135
27	28·03698279	57	76·60774359	87	132·32382060
28	29·48414082	58	78·37117159	88	134·26830327
29	30·94653882	59	80·14202360	89	136·21769328
30	32·42366007	60	81·92017485	90	138·17193579
31	33·91502177	61	83·70550468	91	140·13097718
32	35·42017175	62	85·49789637	92	142·09476501
33	36·93868569	63	87·29723692	93	144·06324796
34	38·47016460	64	89·10341690	94	146·03637581
35	40·01423265	65	90·91633025	95	148·01409942
36	41·57053515	66	92·73587419	96	149·99637065
37	43·13873687	67	94·56194899	97	151·98314238
38	44·71852047	68	96·39445790	98	153·97436846
39	46·30958508	69	98·23330700	99	155·97000365

(5) Mensuration.

$\pi = 3{\cdot}1415926536$ $\qquad \dfrac{1}{\pi} = 0{\cdot}3183098862.$

$\pi^2 = 9{\cdot}8696044$ $\qquad \sqrt{\pi} = 1{\cdot}7724539.$

$\pi^3 = 31{\cdot}0061763$ $\qquad \sqrt[3]{\pi} = 1{\cdot}4645919.$

Lengths of Curves.

1. Circle, radius r .... $L = 2\pi r.$
2. Ellipse, axes $2a$ $2b$ (approximate).............. $L = \pi\sqrt{2(a^2 + b^2)}$? (a and b nearly equal).

Plane Areas.

1. Square, side a.. $A = a^2.$
2. Triangle, base c, perpendicular d............... $A = \dfrac{1}{2}cd.$
3. Rectangle, sides a b .... $A = ab.$
4. Circle, radius r .... $A = \pi r^2.$
5. Ellipse, axes $2a$ $2b$................................ $A = \pi ab.$

Surfaces.

1. Cube, edge a .... $S = 6a^2.$
2. Sphere, radius r.................................... $S = 4\pi r^2.$
3. Cylinder, radius r height h .... $S = 2\pi r(h + r).$
4. Spherical segment, radius r height h .... $S = 2\pi rh.$
5. Cone, slant height l radius r .... $S = \pi r(l + r).$

Volumes.

1. Cube, edge a .... $V = a^3.$
2. Rectangular parallelopiped, edges a b c ..... $V = abc.$
3. Sphere, radius r .... $V = \dfrac{4}{3}\pi r^3.$
4. Spheroid, radii a b b .... $V = \dfrac{4}{3}\pi ab^2.$
5. Cylinder or prism .... $V =$ area of base × height.
6. Cone or pyramid .... $V = \dfrac{1}{3}$ area of base × height.

(6) Measures of Time. (*Cf.* 115)

1 second.
60 secs. = 1 minute.
3600 secs. = 60 mins. = 1 hour.
86400 secs. = 1440 mins. = 24 hrs. = 1 mean solar day.
1 mean solar day = 1·00273791 sidereal days.
1 sidereal day = 86164·1 mean solar seconds.
1 tropical year = 365·24224 mean solar days = 31556929 mean solar seconds.
A mean synodical month is 29·53 mean solar days.

(7) Measures of Angles.

1 second (″).
60″ = 1 minute (′).
3600″ = 60′ = 1 degree (°).
324000″ = 5400′ = 90° = 1 right-angle (rt.).
1296000″ = 21600′ = 360° = 4 rts. = 1 round.

$$1 \text{ radian} = \frac{180^\circ}{\pi} = 57{\cdot}29578^\circ = 3437{\cdot}747' = 206264{\cdot}8'' \text{ nearly.}$$

180° = 3·1416 ? radians.
1° = ·0174533 radian.
A nautical "point" = 11¼°.

(8) Relation between Time and Longitude.

Longitude.	Time.
15″	1 second.
1′	4 seconds.
15′	1 minute.
1°	4 minutes.
15°	1 hour.
90°	6 hours.

The local clock at the western station marks an earlier hour than that at the eastern station.

(9) Measures of Length. (*Cf.* 50)

English.

The Yard is the distance at 62° F. between two marks on a bronze bar deposited with the Board of Trade.

1 inch.
12 inches = 1 foot.
36 inches = 3 feet = 1 yard.
63360 inches = 5280 feet = 1760 yards = 1 statute mile.
73044 inches = 6087 feet = 2029 yards = 1·152 miles = 1 knot or geographical mile.
1 furlong = 10 chains = 220 yards = 1000 links = 7920 inches.

Metric.

The METRE is the length at 0° C. of a platinum bar preserved at Paris and known as the Mètre des Archives.

1 millimetre (mm.).
10 mm. = 1 centimetre (cm.).
100 mm. = 10 cm. = 1 decimetre (dm.).
1000 mm. = 100 cm. = 10 dm. = 1 METRE (m.).
10 m. = 1 decametre.
100 m. = 10 decametres = 1 hectometre.
1000 m. = 100 decametres = 10 hectometres = 1 kilometre (kilom.)

Conversion Table.

1 m. = 39·37079 inches = 3·280899 feet (Kater 1818).
{1 m. = 39·370432 inches = 3·2808693 feet (Clarke 1866)}.

1 inch	.........0·0254 m.	1 mm.	0·03937 inch.
1 foot	.........0·3048 m.	1 metre.........	39·371 inches.
1 yard	.........0·9144 m.	1 metre	3·2809 feet.
1 mile	.........1·6093 kilom.	1 metre	1·0936 yard.
1 knot	.........1·855 kilom.	1 kilom.	0·6214 mile.

(10) MEASURES OF AREA OR SURFACE.

English.

1 square inch.
144 sq. inches = 1 square foot.
1296 sq. inches = 9 sq. feet = 1 square yard.
43560 sq. feet = 4840 sq. yards = 1 acre.
27878400 sq. feet = 3097600 sq. yards = 640 acres = 1 sq. mile.
1 square geographical mile = 1·327 square miles.

Metric.

1 square millimetre (smm.).
100 smm. = 1 square centimetre (scm.).
10000 smm. = 100 scm. = 1 square decimetre (sdm.).
1000000 smm. = 10000 scm. = 100 sdm. = 1 square metre (sm.).
10000 square metres = 100 ares = 1 hectare.

Conversion Table.

1 sq. inch ...6·451 scm.	1 scm.............0·155 sq. inch.
1 sq. foot...929 scm.	1 sm.............10·764 sq. ft.
1 sq. yard ...0·8361 sm.	1 sm. ....1·196 sq. yd.
1 acre ...4046·7 sm.	1 are ....119·6 sq. yd.
1 sq. mile ...2·59 sq. kiloms.	1 hectare ......2·471 acres.
	1 sq. kilom. ...0·3861 sq. mile.

(11) Measures of Volume or Capacity.

English.

A Gallon is the volume occupied by 10 lbs. of water, and a cubic foot of water was found by Miller (1856) to weigh 62·321 lbs., the temperature in each case being 62° F., and the barometric pressure 30 inches.

1 cubic inch.
34·659 cub. inches = 1 pint.
277·274 cub. inches = 8 pts. = 1 gallon = 0·16046 cub. foot.
1728 cub. inches = 49·857 pts. = 6·2321 gals. = 1 cub. foot.
46656 cub. inches = 1346·1 pts. = 168·267 gals. = 27 cub. feet = 1 cub. yard.
5,451,766,000 cub. yards = 1 cubic mile.

Métric.

A Litre is the volume occupied by one kilogram of water at 4° C.; it is very nearly a cubic decimetre.

1 cubic centimetre (ccm.).
1000 ccm. = 1 litre (cubic decimetre) (l.).
1000000 ccm. = 1000 l. = 1 stere (cubic metre).

Conversion Table.

1 cub. inch ....16·386 ccm.	1 ccm. ....·06103 cub. in.
1 pint ....567·93 ccm.	1 litre ...61·027 cub. in.
1 gallon ....4·54346 l.	1 ,, ...1·7608 pints.
1 cub. foot ...28·315 l.	1 ,, ...0·2201 gals.
1 cub. yard ...0·7645 cub. met.	1 ,, ...0·03532 cub. ft.
	1 stere ...1·308 cub. yards.

N.B.—At 39° F. or 4° C. a cubic foot of water weighs *about* 62·4 lbs. According to Rankine (Rules, p. 99) the gallon (= 0·16037 cub. ft.) contains 277·123 cubic inches.

(12) Measures of Mass.

English.

A pound is the mass of a certain piece of platinum deposited with the Board of Trade.

1 grain avoirdupois and troy.
437·5 gr. = 1 ounce avoirdupois (oz.)
7000 gr. = 16 oz. = 1 pound avoirdupois (lb.)
784000 gr. = 1792 oz. = 112 lb. = 1 hundredweight (cwt.)
15680000 gr. = 35840 oz. = 2240 lb. = 20 cwt. = 1 ton.
100 lb. = 1 cental.
480 grains = 1 ounce troy.
5760 gr. = 12 oz. troy = 1 pound troy.
1 oz. troy = 1·097 oz. avoirdupois.
1 lb. avoirdupois = 1·215 lb. troy.
1 ton of water contains 224 gallons or 35·9 cubic feet.

Metric.

The Kilogram is the mass of a piece of platinum at Paris known as the Kilogramme des Archives.

1 milligram (mgm.).
10 mgm. = 1 centigram (cgm.).
100 mgm. = 10 cgm. = 1 decigram (dgm.).
1000 mgm. = 100 cgm. = 10 dgm. = 1 gram (gm.).
1000 gm. = 1 Kilogram (kilog.).
1000000 gm. = 1000 kilog. = 1 tonne.

Conversion Table.

Miller in 1856 found the Kilogramme des Archives to be equal to 15432·349 grains.

1 grain	0·0648 gm.	1 gram	15·432 gr.
1 oz. avoir.	28·35 gm.	1 kilog.	2·2046 lb.
1 oz. troy............	31·1035 gm.	1 tonne	0·9842 ton.
1 lb.	453·593 gm.		
1 cwt.	50·8 kilog.		
1 ton	1016·05 kilog.		

(13) Less usual Measures.—Equivalents.

English.	*English.*	*Metric.*
A fathom (·001 knot)	6·087 ft.	1·855 m.
A cable (100 fathoms)	608·7 ft.	185·5 m.
Mean length of one minute of latitude	6076 ft.	1852 m.
A pole or perch	16·5 ft.	5·029 m.
A rod (sq. perch)	172·25 sq. ft.	25·29 sm.
A rood (40 rods)	10890 sq. ft.	1011·7 sm.
Fluid ounce ($\frac{1}{20}$ pint) apoth.	8 drachms	28·4 ccm.
A bushel	8 gallons	36·35 l.
A dram ($\frac{1}{16}$ oz. avoir.)	27·34 gr.	1·772 gm.
A diamond carat	3·2 gr.	0·207 gm.
French.		
A Paris foot	1·0658 ft.	0·3248 m.
A toise (6 feet)	6·3945 ft.	1·949 m.
An arpent	4089 sq. yards	3419 sm.
A livre = 16 onces (1 on. = 576 grains	1·08 lb.	0·4895 kilog.
German.		
A Rhenish foot	1·0298 ft.	0·3139 m.
An Austrian foot	1·037 ft.	0·3161 m.
A pfund = 16 unzen = 32 loth	1·0311 lb.	0·4677 kilog.
Russian.		
A verst = 500 sachines = 1500 archines	3500 ft.	1·0668 kilom.
A funt = 32 loth	0·9026 lb.	0·4085 kilog.

(14) Ancient Measures.—Approximate Equivalents.

Hebrew, &c.	
Egyptian and Chaldæan cubit	1·502 feet.
Hebrew cubit of the sanctuary	2·125 feet.
Egyptian cubit of Belady and Hebrew Rabbinical cubit (6 cubits = 1 reed)	1·821 feet.
Egyptian royal Artaba	9·44 gallons.
Hebrew Bath or Ephah (= 6 Hins = 100 Omers)	6·468 gallons.
Babylonian silver talent	72·09 lbs.
Babylonian royal talent	131·4 lbs.
Babylonian commercial talent	65·7 lbs.
Babylonian gold talent	108·27 lbs.
Egyptian, Hebrew, and Olympic monetary talent	93·65 lbs.
Egyptian, Hebrew, and Olympic commercial talent	64·73 lbs.

Greek.

A pous	1·01 foot.
Olympic stadium	606·75 feet.
A metretes	16·46 gallons.
A medimnus	18·61 gallons.
Persian and Asiatic Greek talent	71·65 lbs.
Attic commercial talent	64·65 lbs.
Euboic and Attic monetary talent (= 6000 drachmæ)	56·22 lbs.

Roman.

A pes	·97 foot.
A passus (= 5 pedes) (a mile = 1000 passus).........	4·855 feet.
A jugerum	$\frac{5}{8}$ acre ?
An amphora (= 8 congii = 3 modii)	5·725 gallons.
An as or libra (= 12 unciæ)	·7165 lbs.

(15) The Acceleration due to Gravity.

The apparent acceleration, or rate of increase of velocity per second, of a body falling freely *in vacuo* under the action of gravity at any place is denoted by g; which is connected with l, the length of the pendulum beating seconds *in vacuo*, by the formula $g = \pi^2 l$.

	Latitude.	Value of g in cms.	Value of l in cms.
Equator.....................	0° 0′	978·10	99·103
Latitude 45°...............	45° 0′	980·61	99·356
Munich	48° 9′	980·88	99·384
Paris.........................	48° 50′	980·94	99·390
Greenwich	51° 29′	981·17	99·413
Göttingen..................	51° 32′	981·17	99·414
Berlin	52° 30′	981·25	99·422
Dublin	53° 21′	981·32	99·429
Manchester	53° 29′	981·34	99·430
Belfast	54° 36′	981·43	99·440
Edinburgh	55° 57′	981·54	99·451
Aberdeen	57° 9′	981·64	99·461
Pole	90° 0′	983·11	99·610

(16) Various Values of g in Great Britain.

In accurate experiments it is customary to reduce to latitude 45°, where the acceleration due to gravity is taken as having unit value.

Latitude.		Ratio to acceleration at lat. 45°.
	45°	1·000 0000
	50°	1·000 4463
	51°	1·000 5343
Standards' Office	51° 29′ 53″	1·000 57704
	52°	1·000 6217
	53°	1·000 7084
	54°	1·000 7942
	55°	1·000 8790
	56°	1·000 9627
	57°	1·001 0453
	58°	1·001 1266

Densities of Mixtures and Native Compounds.

The density of a solid or liquid is measured by the number of grams in 1 ccm. of it. A cubic foot of water weighs 62·4 lb. For Elements and Artificial Compounds, *see* **80**. Acids, *see* **87**. Alcohol, *see* **88**. Mercury, *see* **32**. Water, *see* **31**.

Agate and Rock crystal	2·6
Albite	2·6
Alcohol (ethyl)	0·795
Aluminium bronze	8
Amber	1·1
Amphibole	2·9–3·4
Anhydrite	2·98
Anthracite	1·4–1·7
Apatite	3·3
Arragonite	2·95
Ash-wood	0·753
Bamboo	0·4
Basalt	2·8
Beech-wood	0·69–·8
Bitumen	0·8–1·2
Blood (human)	1·06
Box-wood	0·96
Bone	1·8–2
Brass	8
Brick	2·1
Bronze (84 cop. 16 tin)	8·56
Bronze coinage	8·66
Calamine	3·4
Celestine	3·9
Chalk	2 ?
Chestnut-wood	0·535
Chloroform	1·526
Cinnabar	8·1
Clay	1·92
Coal (bituminous)	1·27 ?
Coral	2·69
Cork	0·24
Diamond	3·5
Dolomite	2·9
Ebony	1·19
Elm	0·544

Emerald	2·7
Emery	4
Ether $(C_2H_5)_2O$	0·716
Felspar	2·4–2·6
Fluor spar	3·2
Galena	7·6
Garnet	3·5–4·2
Glass (green)	2·64
Glass (crown)	2·5
Glass (flint)	3–3·6
Glass (Faraday's)	4·36
Glycerin	1·26
Gold alloy, 18 carat	14·88
Gold alloy, mint	17·49
Granite	2·7
Graphite	2·2
Gutta percha	0·97
Gypsum	2·33
Heavy spar	4·5
Hematite	5·07
Horn-silver	5·6
Human body (mean)	1·07
Iceland spar	2·7
India-rubber	0·99
Idocrase	3·4
Iron (cast)	7·2
Iron (wrought)	7·79
Iron (Wootz)	7·665
Iron (steel)	7·79
Ivory	1·92
Lard	0·94
Lapis Lazuli	2·4
Lignum vitæ	1·3
Mahogany	0·56·85
Malachite	3·9
Marble	2·7
Mica	2·7–3·1
Milk (cows')	1·03

Oak	0·69–·99
Oil (olive, sperm, colza)	0·915 ?
Opal	1·9–2·3
Pearl	2·7
Petroleum	0·84–·878
Pine-wood	0·56
Porcelain (China)	2·38
Porcelain (Berlin)	2·3
Porcelain (Sèvres)	2·15
Porphyry	2·6–2·9
Pyrites (iron)	5
Pyrolusite	4·9
Pumice stone	2·2–2·5
Ruby	3·6–4
Sand (dry)	1·42
Sea-water	1·026
Selenite	2·3
Serpentine	2·6
Silver (mint 925 fine)	10·38
Slate	2·1–2·8
Spermaceti	0·94
Starch	1·53
Strontianite	3·6
Sugar (cane)	1·6
Suet	0·92
Talc	2·5
Teak (Indian)	0·8
Tinstone	6·9
Topaz	3·6
Tourmaline	2·9–3·3
Trachite	2·75
Turpentine	0·87
Wax (bees')	0·96
Willow-wood	0·4
Witherite	4·3
Wool	1·61
Zinc blende	4·16

(18) Comparative Velocities in Metres per Second.

Five kiloms. per hour..	1·4	Neptune round sun ...	5390
Nine knots per hour...	4·64	Sun towards Hercules...	7642
Ordinary wind	5–6	Jupiter round sun......	12924
21 knots per hour	10·82	Mars round sun.........	23863
A race-horse (·56 mile per min.)...............	15	Earth round sun	29516
Flight of a carrier-pigeon.................	18	Venus round sun	34630
A wave in a tempest...	21·8	Mercury round sun.....	47327
An express (60 miles per hour)	26·8	Solar atmosphere ordinary..................	30000
Sensation through nerves..................	33	Solar atmosphere up to	65000
A hurricane	40	Halley's comet in perihelion	393260
Sound in air at 10° C...	337·2	Tempests in solar atmosphere..............	402000
A point on the equator	463	Electricity in a submarine wire	4000000
A cannon-ball............	500	Electricity in an aërial wire......................	36000000
Maximum tide-rate (North Pacific)	922	Light	300400000
Moon round earth......	1012		
Sound in water at 8° C.	1435		
A point on equator of sun	2028	Earthquake concussion (July '55)..............	1368

(19) Compressibility of Solids and Liquids.

The coefficient of volume-elasticity is the quotient of the pressure in tonnes (1000000 grams) per square centimetre by the compression, *i.e.* by the ratio of the change in volume to the original volume.

Water	15° C.	22·63	Glass	423
Alcohol	15° C.	11·4	Steel	1876
Ether	14° C.	8·07	Iron	1485
Carbon disulphide...	14° C.	16·3	Copper..................	1717
Mercury	15° C.	552·5	Brass (mean)	1063

(20) Rigidity.

The "modulus of rigidity" of a square bar is the amount of tangential stress in tonnes per square centimetre divided by the

deformation which it produces. The deformation is measured by the change (in radians) produced in any one of the four angles of the square bar.

Glass (mean)	150	Copper	456
Glass (flint)	243	Iron (cast)	542
Brass (mean)	350	Iron (wrought)	785
Brass (drawn)	373	Steel	834

(21) Elasticity and Tenacity of Solids.

"Young's modulus of elasticity" (Y) is the amount of end-pull or end-thrust required to produce any very small elongation or contraction of a bar multiplied by the ratio of its length to the elongation or contraction produced.

The tenacity (T) of a substance (density Δ) is the greatest longitudinal stress which it can bear without tearing asunder.

The quotient of the tenacity by Young's modulus gives the greatest longitudinal elastic extension that the substance can bear.

The stresses are given in tonnes (1 000 000 grams) per square centimetre.

	Δ	Y	T	$\frac{T}{Y}$
Slate		910	·675	·00074
		1120	·787	·0007
Brick			·021	
Glass		562	·661	·00117
Deal			·844	
Ash		113	1·2	·0106
Mahogany		88	1·05	·012
Oak		103	1·05	·0102
Red pine		118	·91	·0077
Teak		169	1·05	·0062
Aluminium bronze	7·68		5·13	
Brass (cast)		645	1·27	·00198
Brass (wire)		1001	3·43	·00344
Bronze		696	2·52	·00362
Copper (drawn)	8·933	1245	4·1	·0033
Copper (annealed)	8·936	1052	3·16	·003

	A	Y	T	$\frac{T}{Y}$
Gold drawn	18·513	813	2·66 / 2·84	·0034
Lead (cast)	11·215	177	·22	·0012
Palladium	11·35	1175	2·72	·0023
Platinum wire	21·275	1704	3·5	·002
Silver (drawn)	10·369	736	2·96	·0041
Zinc (drawn)	7·008	873	1·58	·0018
Iron (cast)		984 / 1610	·94 / 2·04	·00096 / ·00126
Iron (wrought bar)		2040	4·22	·00224
Iron (common wire)	7·553	1861	6·51	·0034
Steel (cast)	7·717	1955	8·38	·0043
Steel (cast forged)			5·14	
Steel (English wire)	7·718	1881	9·9	·005
Steel (English pianoforte)	7·727	2049	23·62	·0115
Silk thread		91·39	3·67	·0401

A best hemp rope 1 inch round will carry about 1000 lbs. An iron wire rope an inch round will carry a ton, one two inches round will carry 4 tons. A steel wire rope two inches round will carry 11·2 tons. An Italian tarred hemp rope one inch round will carry ·3 of a ton, one two inches round will carry 1·44 tons. N.B.—The tenacity of ropes does *not* vary exactly as the squares of their radii.

(22) Resistance of Substances to Crushing in Tonnes per Square Centimetre.

Ash	·633
Box	·724
Ebony	1·34
Mahogany	·576
Oak	·703
Teak	·844
Aluminium bronze	9·28
Brass (cast)	·724
Iron (mean, cast)	7·87
Iron (wrought)	2·76
Steel (cast)	18·91
Basalt	·843
Brick (strong red)	·077
Brick (fire)	·12
Chalk	·023
Granite (Mt. Sorrel)	·907
Granite (Argyllshire)	·766
Grauwacke Penmaenmawr	1·188
Limestone (magnesian)	·492 / ·214
Marble	·387
Sandstone (Yorkshire)	·69
Syenite (Mt. Sorrel)	·83

(23) STANDARD WIRE GAUGE. (Board of Trade.)

Number B.W.G.	Diameter in Inches.	Section in Square Inches.	Diameter in Centimetres.	Section in Square Centimetres.
7/0	0·500	0·1963	1·2700	1·2667
6/0	·464	·1691	1·1785	1·0909
5/0	·432	·1466	1·0973	0·9456
4/0	·400	·1257	1·0160	·8107
3/0	·372	·1087	0·9449	·7012
2/0	·348	0·09511	·8839	·6136
0	·324	8245	·8229	·5319
1	·300	7069	·7620	·4560
2	·276	5983	·7010	·3858
3	·252	4988	·6401	·3218
4	·232	4227	·5893	·2727
5	·212	3530	·5385	·2277
6	·192	2895	·4877	·1868
7	·176	2433	·4470	·1570
8	·160	2010	·4064	·1297
9	·144	1629	·3658	·1051
10	·128	1287	·3251	0·08302
11	·116	1057	·2946	6818
12	·104	0·008495	·2642	5480
13	0·092	6648	·2337	4289
14	80	5027	·2032	3243
15	72	4071	·1829	2627
16	64	3217	·1626	2075
17	56	2463	·1422	1589
18	48	1810	·1219	1167
19	40	1257	·1016	0·008107
20	36	1018	0·0914	6566
21	32	0·0008042	813	5188
22	28	6157	711	3972
23	24	4524	610	2922
24	22	3801	559	2452
25	20	3141	508	2027
26	0·018	0·0002545	0·0457	·001641
27	164	2112	4166	1363
28	148	1728	3759	1110
29	136	1453	3454	·0009372
30	124	1208	3150	7791

Number B.W.G.	Diameter in Inches.	Section in Square Inches.	Diameter in Centimetres.	Section in Square Centimetres.
31	0·0116	·0001057	0·02946	0·0006818
32	108	·00009161	2743	5910
33	100	7854	2540	5067
34	0·0092	6648	2337	4289
35	84	5542	2134	3575
36	76	4536	1930	2927
37	68	3632	1727	2343
38	60	2827	1524	1824
39	52	2124	1321	1370
40	48	1810	1219	1167
41	44	1521	1118	·0000982
42	40	1257	1016	811
43	36	1018	0·00914	656
44	32	·00000804	813	519
45	28	616	711	397
46	24	452	610	292
47	20	314	508	203
48	16	201	406	129
49	12	113	305	·0000073
50	10	·000000785	254	507

70 means 0000000.

(24) Miscellaneous Data in Numbers and Measures.

Base of Naperian logarithms (e)	2·718282
Modulus of common logarithms (M)	0·434294
Reciprocal of modulus	2·302585
A "poundal" or British absolute unit of force is the force required to generate per second a velocity of 1 ft. per second or at Greenwich the of oz.	0·497
A foot-pound in kilogram-metres	0·138254
An inch-ton in kilogram-metres	25·8
A kilogram-metre in foot-pounds	7·23308
A "horse-power" can work per second foot-pounds..	550
A "force de cheval" can work per second kilogram-metres	75
A "Watt" can work per second foot-pounds	0·737
A horse-power in forces de cheval	1·01386
A force de cheval in horse-powers	0·98633

Acceleration due to gravity (g) at Greenwich in foot-seconds	32·1908
Length of the pendulum (l) beating seconds at Greenwich in inches	39·139
A cubic foot of water at 39° F. weighs in pounds	62·425
A cubic foot of water at 39° F. weighs in ounces	998·8
Legal mass of a cubic foot of water at 62° F. in lb.	62·321
Mass in lb. of a cub. ft. of water at 62° F. calc. from Rossetti's results (*cf.* **32**)	62·355
A cubic inch of water at 62° F. weighs in grains	252·6
A pound of water at 39° F. occupies in cubic feet	·016019
A pound of water at 62° F. occupies in cubic feet	·016037
A ton of sea-water occupies in cubic feet	35
A ccm. of water at 4° C. weighs in grams (Kupffer)	1·000013
Mass of a cubic foot of air at 32° F. in lb.	0·080728
Mass of a litre of air at 0° C. in grams	1·2932
A pound of air at 62° F. occupies in cubic feet	13·14
Height of the homogeneous atmosphere in feet	27801
The normal pressure of the air (H) in mm. of mercury	760
The normal pressure of the air (H) in inches of mercury	29·922
The normal pressure of the air (H) in kilogs. per scm.	1·0333
The normal pressure of the air (H) in lb. per sq. inch	14·7
Mass of a sovereign ($\frac{1}{12}$ copper) in grains	123·274
A halfpenny one inch in diameter weighs in oz.	0·2
A penny $\frac{1}{3}$ of an ounce weighs in grams	9·46
Five shillings or ten sixpences weigh in ounces	1
A radian per second in turns per second	0·159155
A turn per second in radians per second	6·2832

HEAT.

(25) Conversion of Temperatures.

°F	°C	°F	°C	°F	°C	°F	°C
−40	−40	194	90	428	220	662	350
−31	−35	203	95	437	225	671	355
−22	−30	212	100	446	230	680	360
−13	−25	221	105	455	235	689	365
− 4	−20	230	110	464	240	698	370
5	−15	239	115	473	245	707	375
14	−10	248	120	482	250	716	380
23	− 5	257	125	491	255	725	385
32	0	266	130	500	260	734	390
41	5	275	135	509	265	743	395
50	10	284	140	518	270	752	400
59	15	293	145	527	275	761	405
68	20	302	150	536	280	770	410
77	25	311	155	545	285	779	415
86	30	320	160	554	290	788	420
95	35	329	165	563	295	797	425
104	40	338	170	572	300	806	430
113	45	347	175	581	305	815	435
122	50	356	180	590	310	824	440
131	55	365	185	599	315	833	445
140	60	374	190	608	320	842	450
149	65	383	195	617	325	851	455
158	70	392	200	626	330	860	460
167	75	401	205	635	335	869	465
176	80	410	210	644	340	878	470
185	85	419	215	653	345	887	475

°C	°F
1	1·8
2	3·6
3	5·4
4	7·2

°F	°C	°F	°C
1	0·5556	5	2·7778
2	1·1111	6	3·3333
3	1·6667	7	3·8889
4	2·2222	8	4·4444

$x°$ absolute $= a°C + 273$.

(26) Melting Point, Specific Heat, Coefficients of Linear and Cubical Expansion of Solids.

	M. p. °C.	Sp. ht.	Linear exp. ·0000	Cub. exp. ·000
Aluminium	600 ?	·202	2221	
Antimony	440	·0507	098 1129	0317
Arsenic	210	·0814	0559	
Baily's metal			1774	
Bismuth	265	·0305	133	04
Brass	1015 ?	·0939 ?	1894	0172 ?
Brick			055	
Brick, fire			049	
Cadmium	500	·0548	316	094
Copper	1050	·095	1666	05
Ebonite			77	
Glass		·198 ?	089 ?	023 ?
Gold	1250	·0324	1415	04411
Granite			08685	
Graphite		·254 ·467	0786	
Ice	0	·5	52	1585
Iridium	1950	·0303	0641	
Iron	1600	·112	1166	0355
Lead	335	·0315	28	084
Magnesium	750	·245	2694	
Marble (white)		·21	107 0849	
Mercury (solid)	– 39·5	·03192		
Pinewood			0496	
Platinum	1700	0324 0388	0863 0886	026
Platinum 90°/o, iridium 10°/o			0857	
Porcelain			036 ?	
Quartz		·19	1154 ?	04
Sandstone (red)			1174	
Silver	1000	·0559	1943	0583
Slate			1038	
Sodium	95·6	·2934		204
Steel	1350	·118	1095 1144	
Sulphur	114·5	·184	6413	223
Tin	235	·0559	209	069
Zinc	450	·0935	2976	089

(27) Boiling Point, Specific Heat, and Mean Coefficient of Cubical Expansion of some Liquids.

	B. p. °C.	Sp. ht.	Coeff. exp.	Between.
Alcohol (amyl)	131·8	·564	·00109	0—124
Alcohol (ethyl)	78·3	·615	·00108	0—50
Alcohol (methyl)	66·3	·613	·001358	0—61
Aniline	183·7		·000915	7—154
Benzene	80·8	·45	·001385	11—81
Bromine	63	·107	·001219	0—59
Calcium chloride (sat. sol.)	179·5			
Chloroform	61·2	·233	·0014	0—63
Carbon disulphide	48	·2206	·001468	-34—60
Ether $(C_2H_5)_2O$	35·5	·517	·0021	0—33
Glycerin	290			
Hydrogen acetate	120	·508		
Hydrogen nitrate	86	·445		
Hydrogen chloride (sat. sol.)	110	·749	·00049	
Hydrogen iodide (sat. sol.)	128			
Hydrogen sulphate	326	·33	·000489	0—30
Mercury	350	·0333	·00018	0—100
Nitrobenzene	213	·35	·00089	144—164
Paraffin	370 ?	·683		
Phenol	188		·00084	0—100
Phosphorus	290	·2 ?	·0005	50—60
Sea-water	103·7			
Sulphur	440	·2346		
Sulphur chloride (S_2Cl_2)	136	·2024	·001	0—100
Turpentine	156	·467	·00105	-9—106

(28) Specific Heat of Gases.

The specific heat of a gas is the number of calories (40) required to raise 1 kilog. of it from 0° C. to 1° C. If c_p represent the specific heat at constant pressure, and c_v that at constant volume, $\frac{c_p}{c_v} = 1·421$ for air, 1·41 for gases the molecule of which contains two atoms, 1·26 if the molecule contains three, and 1·66 if the molecule contains only one atom. These numbers are only approximate.

		c_p	c_v
Air		0·2375	0·1684
Oxygen	O_2	0·2175	0·1551
Nitrogen	N_2	0·2438	0·1727
Hydrogen	H_2	3·409	2·411
Chlorine	Cl_2	0·121	0·0928
Bromine	Br_2	0·0555	0·0429
Nitrous oxide	N_2O	0·2262	0·181
Nitric oxide	NO	0·2317	0·1652
Carbon monoxide	CO	0·245	0·1736
Carbon dioxide	CO_2	0·2169	0·172
Hydrogen chloride	HCl	0·1852	0·1304
Steam	H_2O	0·4805	0·37
Sulphur dioxide	SO_2	0·1544	0·123
Hydrogen sulphide	H_2S	0·2432	0·184
Carbon disulphide	CS_2	0·1569	0·131
Marsh gas	CH_4	0·5929	0·468
Olefiant gas (ethene)	C_2H_4	0·4040	0·359
Ammonia	NH_3	0·5084	0·391
Benzene	C_6H_6	0·3754	0·35
Alcohol (methyl)	CH_4O	0·4580	0·395
Alcohol (ethyl)	C_2H_6O	0·4534	0·41
Ether	$C_4H_{10}O$	0·4797	0·453
Turpentine	$C_{10}H_{16}$	0·5061	0·491

(29) Tension and Boiling-Points of Liquefied Gases.

	B.-p.	Press. at 0° C. in cm.		B.-p.	Press. at 0° in cm.
Acetylene		3640	Chlorine	− 33·6°	456
Nitrous oxide ..	− 87·9°	2742	Ammonia	− 38·5°	318
Carbon dioxide.	− 78·2°	2691	Cyanogen	− 20·7°	204
Hydrogen chloride		1991	Sulphur dioxide	− 10°	116·5
Hydrogen sulphide	− 61·8°	821			

Hydrogen at	− 140° C.	650 atmos.
Oxygen at	− 140° C.	252 atmos.
Nitric oxide at	− 11° C.	104 atmos.

(30) Latent Heats of Fusion and Vaporisation.

Liquids.		*Vapours.*	
Water	79·25	Steam	536
Beeswax	97·22	Methyl alcohol	264
Spermaceti	82·22	Ethyl alcohol............	209
Zinc	28·13	Hydrogen formate......	168
Silver	21·07	Hydrogen acetate	102
Tin	14·25	Ethyl oxide (Ether) ...	91
Cadmium	13·55	Carbon disulphide......	86·7
Bismuth	12·64	Turpentine	69
Sulphur	9·35	Bromine	45·6
Lead	5·37	Mercury	62
Phosphorus............	5·245	Sulphur	362
Mercury	2·83	Chloroform at 100° C..	80·7
Grey cast iron.........	23		
Platinum..............	27·18		
Sea-water	54		

(31) The Logarithms of 1 + ·00367 *t*.

t^o	log.	D	t^o	log.	D	t^o	log.	D
− 30	$\bar{1}$·9493	18	45	·0664	14	205	·2436	9
− 20	$\bar{1}$·9669	17	50	·0732	13	210	·2481	
− 10	$\bar{1}$·9838	16	55	·0799		215	·2526	
0	·0000		60	·0864		220	·2571	
1	·0016		65	·0929		225	·2614	
2	·0032		70	·0993	13	230	·2658	9
3	·0048		75	·1056	12	235	·2701	8
4	·0063		80	·1118		240	·2743	
5	·0079		85	·1179		245	·2786	
6	·0095		90	·1239		250	·2827	
7	·0110		95	·1299	12	255	·2869	
8	·0126		100	·1358	11	260	·2910	
9	·0141		105	·1416		265	·2950	
10	·0156		110	·1473		270	·2991	
11	·0172		115	·1529		275	·3030	
12	·0187		120	·1585		280	·3070	
13	·0202		125	·1640		285	·3109	
14	·0218	16	130	·1694		290	·3148	8
15	·0233	15	135	·1748	11	295	·3186	7
16	·0248		140	·1801	10	300	·3224	
17	·0263		145	·1853		305	·3262	
18	·0278		150	·1905		310	·3299	
19	·0293		155	·1956		315	·3337	
20	·0308		160	·2006		320	·3373	
21	·0322		165	·2056		325	·3410	
22	·0337		170	·2106		330	·3446	
23	·0352		175	·2154	10	335	·3482	
24	·0367		180	·2203	9	340	·3518	
25	·0381	15	185	·2250		345	·3553	7
30	·0454	14	190	·2298		350	·3588	
35	·0525		195	·2344		440	·4174	
40	·0595		200	·2391	9	860	·6187	
						1040	·6828	

(32) Volume and Density of Water from the Mean of all the best Experiments.

t° C.	Rossetti. Volume at 4° C. = 1.	True density grams in 1 ccm.	Volume in ccm. of 1 gram.	Förster. Volume at 4° C. = 1.
0	1·000129	·999884	1·000116	
1	1·000072	·999941	1·000059	
2	1·000031	·999982	1·000018	
3	1·000009	1·000004	·999996	
4	1·000000	1·000013	·999987	1·0000000
5	1·000010	1·000003	·999997	83
6	1·000030	·999983	1·000017	312
7	1·000067	·999946	1·000054	688
8	1·000114	·999899	1·000101	1205
9	1·000176	·999837	1·000163	1860
10	1·000253	·999760	1·000240	2650
11	1·000345	·999668	1·000332	3575
12	1·000451	·999562	1·000438	4630
13	1·000570	·999443	1·000557	5806
14	1·000701	·999312	1·000688	7110
15	1·000841	·999173	1·000828	8533
16	1·000999	·999015	1·000986	10075
17	1·001160	·998854	1·001147	11731
18	1·001348	·998667	1·001335	13499
19	1·001542	·998473	1·001529	15375
20	1·001744	·998272	1·001731	17355
21	1·001957	·998060	1·001944	19438
22	1·002177	·997839	1·002164	21623
23	1·002405	·997614	1·002392	23901
24	1·002641	·997380	1·002628	1·0026274
25	1·002888	·997133	1·002875	
26	1·003144	·996879	1·003131	
27	1·003408	·996616	1·003395	
28	1·003682	·996344	1·003669	
29	1·003965	·996064	1·003952	
30	1·004253	·995778	1·004240	
40	1·00770	·99236	1·007682	
50	1·01195	·98821	1·011928	
60	1·01691	·98339	1·016906	
70	1·02256	·97795	1·022542	
80	1·02887	·97195	1·028856	
90	1·03567	·96557	1·035662	
100	1·04312	·95866	1·043117	

(33) Volume and Density of Mercury.

t° C.	Volume of mercury at 0° C. = 1.	Density or grams in 1 ccm.	Ccm. occupied by 1 gram.	Diff.
0	1·000000	13·596	·073551	13
4	1·000716	13·586	·073605	
5	1·000896	13·584	·073617	
10	1·001792	13·572	·073681	
15	1·002691	13·559	·073752	
20	1·003590	13·547	·073817	
30	1·005393	13·523	·073953	
40	1·007201	13·499	·074085	
50	1·009013	13·474	·074217	
60	1·010831	13·450	·074349	
70	1·012655	13·426	·074482	
80	1·014482	13·401	·074621	
90	1·016315	13·377	·074755	
100	1·018153	13·353	·074890	

(34) Tension of Aqueous Vapour in mm. of Mercury.

t° C.	mm.	t° C.	mm.	t° C.	mm.	t° C.	Atmos.
−10	2·08	16	13·54	90	525·39	100	1·0
−9	2·26	17	14·42	95	633·69	110	1·4
−8	2·46	18	15·36	99	733·21	120	1·96
−7	2·67	19	16·35	99·1	735·85	130	2·67
−6	2·89	20	17·39	99·2	738·50	140	3·57
−5	3·13	21	18·50	99·3	741·16	150	4·7
−4	3·39	22	19·66	99·4	743·83	160	6·1
−3	3·66	23	20·89	99·5	746·50	170	7·8
−2	3·96	24	22·18	99·6	749·18	180	9·9
−1	4·27	25	23·55	99·7	751·87	190	12·4
0	4·60	26	24·99	99·8	754·57	200	15·4
1	4·94	27	26·51	99·9	757·28	210	18·8
2	5·30	28	28·10	100	760·00	220	22·9
3	5·69	29	29·78	100·1	762·73	230	27·5
4	6·10	30	31·55	100·2	765·46		
5	6·53	35	41·83	100·3	768·20		
6	7·00	40	54·91	100·4	771·95		
7	7·49	45	71·39	100·5	773·71		
8	8·02	50	91·98	100·6	776·48		
9	8·57	55	117·48	100·7	779·26		
10	9·17	60	148·79	100·8	782·04		
11	9·79	65	186·94	100·9	784·83		
12	10·46	70	233·08	101	787·59		
13	11·16	75	288·50	105	906·41		
14	11·91	80	354·62	110	1075·37		
15	12·70	85	433·00				

(35) The Wet-bulb Hygrometer.

The tension of aqueous vapour in mm. of mercury corresponding to the reading $t°$ C. of the dry-bulb thermometer for the differences in temperatures between the dry and wet-bulb thermometers given in the upper line.

$t°$ C.	0	1	2	3	4	5	6	7	8	9	10	11
0	4·6	3·7	2·9	2·1	1·3							
1	4·9	4·0	3·2	2·4	1·6	0·8						
2	5·3	4·4	3·4	2·7	1·9	1·0						
3	5·7	4·7	3·7	2·8	2·2	1·3						
4	6·1	5·1	4·1	3·2	2·4	1·6	0·8					
5	6·5	5·5	4·5	3·5	2·6	1·8	1·0					
6	7·0	5·9	4·9	3·9	2·9	2·0	1·1					
7	7·5	6·4	5·3	4·3	3·3	2·3	1·4	0·4				
8	8·0	6·9	5·8	4·7	3·7	2·7	1·7	0·8				
9	8·6	7·4	6·3	5·2	4·1	3·1	2·1	1·1	0·2			
10	9·2	8·0	6·8	5·7	4·6	3·5	2·5	1·5	0·5			
11	9·8	8·6	7·4	6·2	5·1	4·0	2·9	1·9	0·9			
12	10·5	9·2	8·0	6·8	5·6	4·5	3·4	2·3	1·3			
13	11·2	9·8	8·6	7·3	6·2	5·0	3·9	2·8	1·7			
14	11·9	10·6	9·2	8·0	6·7	5·6	4·4	3·3	2·2	1·1		
15	12·7	11·3	9·9	8·6	7·4	6·1	5·0	3·8	2·7	1·6	0·5	
16	13·5	12·1	10·7	9·3	8·0	6·8	5·5	4·3	3·2	2·1	1·0	
17	14·4	13·0	11·5	10·1	8·7	7·4	6·2	4·9	3·7	2·6	1·5	0·4
18	15·4	13·8	12·3	10·9	9·5	8·1	6·8	5·5	4·3	3·1	2·0	0·9
19	16·4	14·7	13·2	11·7	10·3	8·9	7·5	6·2	4·9	3·7	2·5	1·4
20	17·4	15·7	14·1	12·6	11·1	9·7	8·3	6·9	5·6	4·3	3·1	1·9
21	18·5	16·8	15·1	13·5	12·0	10·5	9·0	7·6	6·3	5·0	3·7	2·5
22	19·7	17·9	16·2	14·5	12·9	11·4	9·9	8·4	7·0	5·7	4·4	3·1
23	20·9	19·0	17·3	15·6	13·9	12·3	10·8	9·2	7·8	6·4	5·1	3·8
24	22·2	20·3	18·4	16·6	14·9	13·3	11·7	10·1	8·7	7·2	5·8	4·5
25	23·6	21·6	19·7	17·8	16·0	14·3	12·7	11·1	9·5	8·0	6·6	5·2
26	25·0	22·9	21·0	19·0	17·2	15·4	13·7	12·1	10·5	8·9	7·4	6·0
27	26·5	24·9	22·3	20·3	18·4	16·6	14·8	13·1	11·4	9·8	8·3	6·8
28	28·1	25·9	23·7	21·7	19·7	17·6	16·0	14·2	12·5	10·8	9·2	7·7
29	29·8	27·5	25·3	23·1	21·1	19·1	17·2	15·3	13·6	11·9	10·2	8·6
30	31·6	29·2	26·9	24·6	22·5	20·5	18·5	16·6	14·7	13·0	11·2	9·6

(36) Mass of Aqueous Vapour, Air, and Saturated Air.

Grams in one cubic m.				Grains in one cubic foot.			
°C.	Aq. vap. own pres.	Dry air 1 atmos.	Sat. air 1 atmos.	°F.	Aq. vap. own pres.	Dry air 1 atmos.	Sat. air 1 atmos.
0	4·8	1293·2	1293·2	32	2·1	565·1	565·1
5	6·9	1269·5	1265·9	41	3·0	554·9	553·3
10	9·4	1247·1	1241·7	50	4·1	545·1	542·7
15	12·8	1225·1	1217·9	59	5·6	535·5	532·3
20	17·2	1204·4	1193·6	68	7·5	526·4	521·7
25	22·9	1184·3	1169·6	77	10·0	517·6	511·2
30	30·0	1164·6	1144·9	86	13·1	509·0	500·4
35	39·4	1145·6	1120·0	95	17·2	500·7	489·5
40	50·6	1127·3	1093·2	104	22·1	492·7	477·8

(37) Tension of Mercury-Vapour.

t° C.	mm.	t° C.	mm.
100	0·75	220	34·70
110	1·07	230	45·35
120	1·53	240	58·82
130	2·18	250	75·75
140	3·06	260	96·73
150	4·27	270	123·01
160	5·90	280	155·17
170	8·09	290	194·46
180	11·00	300	242·15
190	14·84	310	299·69
200	19·90	320	368·73
210	26·35	330	450·91

(38) Molecular Data for Gases.

	Hydrogen.	Oxygen.	Carbon monoxide.	Carbon dioxide.
Mass of the molecule if $H_2 = 2$	2	32	28	44
Velocity (square root of mean square) in metres per second at 0° C.	1859	465	497	396
Mean path in tenth-metres	965	560	482	379
Collisions per second in millions	17750	7646	9489	9720
Diameter in tenth-metres	5·8	7·6	8·3	9·3
Mass (in 10^{-25} of a gram).	46	736	644	1012

(39) Thermal Conductivities.

The number of gram-degrees of heat which pass in a second through a plate of the substance 1 cm. square and 1 cm. thick, the opposite faces being kept at temperatures differing by 1° C.

Copper	0·96	Water	·002
Iron	0·2	Fir across fibres	·00026
Air, Oxygen, Nitrogen, Carbon monoxide	·000049	Fir along fibres	·00047
Carbon dioxide	·000038	Oak across fibres	·00059
Hydrogen	·00034	Cork	·000029
Strata (rough general)	·005	Writing-paper sized	·00019
Sandstone	·01	Grey paper unsized	·000094
Sand	·0026	Calico (new)	·000139
		Carded wool	·000122
		Cotton wool	·000111
		Eider down	·000108

(40) Miscellaneous Data in Heat.

A calorie (kilog. water through 1° C.) in lbs. heated through 1° F.	3·968
A British unit of heat in calories	0·252
Mechanical equivalent of British unit of heat in foot-lbs.	775·47
Mechanical equivalent of a calorie in kilog.-metres	425·454
Mechanical equivalent of a water-gram-degree in ergs	$4{\cdot}175 \times 10^7$
Mass of 1 ccm. of aqueous vapour at 0° C. and 760 mm. in grams	·000806

Coefficient of expansion of air (volume constant)	$\frac{1}{273}$
Coefficient of expansion of air (pressure constant) ...	$\frac{11}{3000}$
Coefficient of expansion of mercury (0° – 100°) ...	$\frac{1}{5550}$ ·0001802
Coefficient of apparent expansion of mercury in glass	$\frac{1}{6480}$

LIGHT.

(41) Wave lengths of the chief lines in the spectra of the sun and of the more volatile metals in ten-millionths of a mm. or 1^{-10} m.

THE SOLAR SPECTRUM.

Limit of heat-spectrum...	19400
Red	7230 6470
Orange	5850
Yellow	5750
Green	4920
Blue...............	4550
Indigo	4240
Violet	3970
Limit of ultra-violet sp. U.	2948
Atmospheric ....A.	7604
Atmospheric ....B.	6867
Hydrogen ....C.	6562
Sodium.................D	5895 5889
E.	5269
Magnesium ....b_1	5183
Hydrogen ....F.	4861
,, ...G_1.	4340
Iron.......................G.	4307
Hydrogen ....*h*.	4101
Calcium ....H.	3967
,, ... (H_2) or K.	3933
Iron.......................L.	3819
Barium	5535 6031 5866 5492
Hydrogen borate	5480

Calcium	6202 6181 5543 5517
Cæsium	6219 6007 4597 4560
Indium	4511 4101
Lithium	6705 6102
Magnesium	5183 5172 5167
(with metal)	4483
Potassium..................	7680 4045
Rubidium	7800 6297 4216 4202
Sodium	5895 5889
Strontium..................	6627 6364 6058 6031 4607
Thallium	5349 5680

D

(42) Refractive Indices chiefly for the Mean D Line.

Solids.	
Lead chromate	2·5 ?
Diamond	2·42
Phosphorus	2·22
Native sulphur	2·04
Lead borate	1·86
Ruby	1·71
Iceland spar (ord.)	1·658
,, ,, (ext.)	1·486
Topaz	1·61
Flint glass	1·6
Emerald	1·58
Quartz (ord.)	1·544
,, (ext.)	1·553
Rock salt	1·54
Resin	1·54
Citric acid	1·53
Canada balsam	1·53
Felspar	1·52
Potassium nitrate	1·52
Potassium sulphate	1·51
Ferrous sulphate	1·5
Crown glass	1·5
Magnesium sulphate	1·49
Fluor spar	1·43
Ice	1·31
Liquids.	
Phosphorus	2·075
Carbon disulphide	1·63
Oil of bitter almonds	1·6
Oil of cassia	1·58
Aniline	1·57
Phenol	1·55
Nitrobenzene	1·54
Benzene	1·49
Glycerin	1·47
Turpentine	1·46
Chloroform	1·44
Sulphuric acid	1·42
Alcohol (amyl)	1·4
Alcohol (ethyl)	1·36
Ether (ethyl)	1·35
Water	1·33
Alcohol (methyl)	1·33
Gases and Vapours (white light).	
Air	1·000294
Oxygen	1·000272
Hydrogen	1·000138
Nitrogen	1·0003
Chlorine	1·000772
Nitrous oxide	1·000503
Nitric oxide	1·000303
Hydrogen chloride	1·000449
Carbon monoxide	1·000340
Carbon dioxide	1·000449
Cyanogen	1·000834
Marsh gas	1·000443
Olefiant gas	1·000678
Ammonia	1·000385
Carbonyl chloride	1·001159
Hydrogen sulphide	1·000644
Sulphur dioxide	1·000665
Sulphur	1·001629
Phosphorus	1·001364
Arsenic	1·001114
Mercury	1·000556

(43) Rotatory Polarisation.

The amount of rotation very nearly varies inversely as the square of the wave-length of the light used.

In the case of the solution of an active substance in an inactive liquid the "specific rotation for light" of wave-length x.

$[a]_x = \frac{a}{lw} \times v$ where a is the observed angle, v the volume of

the solution, l the length of the solution in decimetres, and w the mass of the active substance. (+) right-handed and (−) left-handed rotation. The rotation required to reproduce the sensitive tint s.t., which is the peculiar grey given when the yellow is absorbed from white light, is equal to that of the mean D line.

Rock crystal 1 mm.	D	±	20·98°
Rock crystal, sensitive tint		±	24°
Cinnabar, 2 mm.	B	±	52°
Strychnine sulphate + 13 aq. 1 mm.	B	−	9°
Sodium chlorate 2·25 mm.		±	8·2°
Potassium thiosulphite, 1 mm.		±	8·83°
Cane sugar	s.t.	+	73·8°
Levulose	s.t.	−	106°
Glucose	s.t.	+	56°
Milk sugar	s.t.	+	59°
Mannite	D	−	0·15°
Camphor in alcohol	s.t.	+	47·4°
Dextrin	D	+	138·7°
Turpentine	D	−	43·5°
Tartaric acid	D	±	9·6°
Ammonium tartrate	D	+	29°
Egg albumin	D	−	35·5°
Amyl alcohol	D	−	4·38°
Quinine sulphate	(red)	−	147·7°
Strychnine	(red)	−	132°

(44) The Velocity of Light in Metres per Second.

Römer (1676), eclipses of Jupiter's satellites	310 000 000
By aberration of the fixed stars (20·445″)	305 600 000
Fizeau, (telescopes and toothed wheel)	315 000 000
Foucault (1862), (revolving mirror in air)	298 000 000
Cornu (1873) in air	298 400 000
,, (1873) *in vacuo*	298 500 000
,, (1874) in air	299 740 000
,, (1874) *in vacuo*	300 400 000
Michelson (1879) in air	299 740 000
,, (1879) *in vacuo*	299 820 000

Hence the velocity of light *in vacuo* most probably is $3{\cdot}004 \times 10^5$ kilom. or 189000 miles per second. The denser the medium through which the light is passing the *less* is the velocity. If μ be the absolute refractive index of light of a given refrangibility in any medium, the velocity is $\frac{300400000}{\mu}$ metres per second.

SOUND.

(45) Velocity of Sound in Metres per Second.

In air at t° C. 332·4 + ·6t metres = 1093 feet ?

In Gases at 0° C.	
Hydrogen	1269
Oxygen	317
Carbon monoxide	337
Carbon dioxide	362
Nitrous oxide	262
Ethylene	314
In Liquids.	
Water at 8° C.	1435
Absolute alcohol	1160
Ether	1160
In Solids.	
Lead	1332
Tin	2464
Gold	1998
Silver	2664
Platinum	2664
Zinc	3230
Oak	3330
Copper	3730
Brass	3397
Flint Glass	3996
Glass	4995
Iron	5028
Steel	5028
Fir	4163 to 5661
Aspen	5080

(46) The Diatonic Scale.

Proportional number of vibrations of	Fund.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Octave.
	C	D	E	F	G	A	B	C
Upper note		9	5	4	3	5	15	2
Lower note	1	8	4	3	2	3	8	1
Intervals		$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	$\frac{2}{1}$

(47) The Number of Complete Vibrations for each Note of the Middle Octave of an Ordinary Piano.

		(1)	(2)	(3)	(4)	References.
Do	C	1·000	264	258·7	273	(1.) Ratio of no. vibrations
Re	D	1·125	297	291·0	307·1	(2.) Stuttgart Congress and Society of Arts.
Mi	E	1·25	330	323·4	341·3	
Fa	F	$1{\cdot}\dot{3}$	352	344·9	364	(3.) Paris Conservatoire.
Sol	G	1·5	396	388·0	409·5	(4.) Italian opera.
La	A	$1{\cdot}\dot{6}$	440	431·1	455	A minor semitone $\frac{25}{24}$.
Si	B	1·875	495	485·0	512·9	A major semitone $\frac{16}{15}$.
Do	C	2·000	528	517·3	546	A comma $\frac{81}{80}$.

(48) Comparison of the Diatonic and Equally Tempered Scales.

The octave is divided into six hundred equal intervals, and the columns on the right give the numbers of such intervals by which the several notes in each scale are higher than the fundamental note.

Diatonic.		Intervals.	Diat.	Temp.
Do	1	Unison	0	0
♯	$\frac{81}{80}$	Comma	11	11
Do♯	$\frac{25}{24}$	Semitone	35	50
Re♭	$\frac{27}{25}$	Minor second	67	
Re	$\frac{9}{8}$	Major second	102	100
Re♯	$\frac{75}{64}$	Augmented second	137	150
Mi♭	$\frac{6}{5}$	Minor third	158	
Mi	$\frac{5}{4}$	Major third	193	200
Fa♭	$\frac{32}{25}$	Minor fourth	214	
Mi♯	$\frac{125}{96}$	Augmented third	228	250
Fa	$\frac{4}{3}$	Perfect fourth	249	
Fa♯	$\frac{25}{18}$	Augmented fourth (tritone)	284	300
Sol♭	$\frac{36}{25}$	Minor fifth	316	
Sol	$\frac{3}{2}$	Major fifth (perfect)	351	350
Sol♯	$\frac{25}{16}$	Augmented fifth	386	400
La♭	$\frac{8}{5}$	Minor sixth	407	
La	$\frac{5}{3}$	Major sixth	442	450
La♯	$\frac{125}{72}$	Augmented sixth	478	500
Si♭	$\frac{9}{5}$	Minor seventh	509	
Si	$\frac{15}{8}$	Major seventh	544	550
Do♭$_1$	$\frac{48}{25}$	Minor octave	565	
Si♯	$\frac{125}{64}$	Augmented seventh	579	600
Do$_1$	2	Octave	600	

ELECTRICITY.

(49) THE DIMENSIONS OF UNITS.

If any physical quantity Q be measured in terms of a length L, an interval of time T, and a mass M, so that

$$Q = L^{\alpha} T^{\beta} M^{\gamma}$$

the quantity Q is said to be of the *dimension* α in length, β in time, and γ in mass.

The velocity (v) of a moving body is measured by the linear space passed over in the unit of time. Acceleration or velocity-increment (a) is measured by the increase or decrease in the velocity of the moving body during the unit of time. Force (F), anything which changes or tends to change the motion of a body, is measured by the mass moved multiplied by the acceleration produced. Work (W) is measured by the force multiplied by the distance through which it acts. The energy of a system is measured by the work which it can do, hence energy also is measured by force multiplied by distance. The power (P) of a motor is measured by the rate at which it works, that is by the work done in the unit of time.

	Geometry.	Dimensions.
Length	L	L^1
Surface	$S = L^2$	L^2
Volume	$V = L^2$	L^3
	Kinematics.	
Time	T	T^1
Velocity	$= \frac{L}{T}$	$L^1 T^{-1}$
Acceleration	$a = \frac{v}{T}$	$L^1 T^{-2}$
	Kinetics.	
Mass	M	M^1
Momentum	Mv	$L^1 M' T^{-1}$
Force	$F = aM$	$L^1 M' T^{-2}$
Work and Energy	$W = LF = \frac{1}{2} M v^2$	$L^2 M T^{-2}$
Power	$P = \frac{W}{T}$	$L^2 M^{-1} T^{-3}$
Density	$\frac{M}{V}$	$L^{-3} M$

(50) THE C.G.S. SYSTEM. (*Cf.* 9.)

To obtain uniformity of measures it is convenient to adopt:—

The CENTIMETRE as the unit of length.
The GRAM as the unit of mass.
The mean solar SECOND as the unit of time.

Measures expressed on this system are denoted by C.G.S. The unit of velocity is one centimetre per second. The unit of acceleration is that in which unit velocity (one centimetre per second) is added (algebraically) per second.

The unit of force, called the DYNE, is the force which acting on a gram for a second produces in it a velocity of a centimetre per second. Since a body after falling from rest for a second at Greenwich has a velocity of 981 cms. per second, a dyne is $\frac{1}{981}$ of the weight of a gram at Greenwich, or 1000 dynes are about the weight of 1·019 gram.

The unit of work, called the ERG, is the amount of work done by a dyne in acting through one centimetre. Energy is measured by the work which it can do, and is therefore also expressed in ergs. (For the unit of power called the Watt *cf.* 58.)

Since very large and very small quantities have to be expressed by means of the same unit, it is convenient to use the prefix mega- or megal- to express a million times the unit ($\times\ 10^6$), and the prefix micro- to express a millionth part of the unit ($\times\ 10^{-6}$).

Thus a megadyne means 1,000,000 dynes (rather more than the weight of a kilogram, and a megalerg means 1,000,000 ergs (rather more than ·01 kilogram-metre).

(51) Magnetic Units.

The unit magnetic pole is one of such a strength that it repels an equal pole at the distance of one centimetre with the force of one dyne.

Unit difference of magnetic potential exists between two points when an erg of work must be expended to bring a unit N-seeking pole from the one point to the other against the magnetic forces.

A field of unit intensity is one which acts on a unit N-seeking pole with the force of one dyne.

Magnetic density is measured by the number of unit poles the magnetism per unit of surface is equivalent to.

The moment of a magnet is nearly the product of the strength of either of its poles by the distance between them. The intensity of magnetisation of a uniformly magnetised body is the quotient of its moment by its volume.

		Dimensions.
Strength of pole	p = (force × distance²)$^{\frac{1}{2}}$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}$
Potential	v = work ÷ strength of pole	$L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$
Intensity of field	i = force ÷ strength of pole	$L^{-\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$
Magnetic moment	lp = length × strength of pole	$L^{\frac{5}{2}}M^{\frac{1}{2}}T^{-1}$
Intensity of magnetisation	j = moment ÷ volume	$L^{-\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$

(52) Electrostatic Units.

The C.G.S. electrostatic unit of quantity or charge is that quantity of electricity (q) which would repel an equal quantity at the distance of one centimetre in air with the force of one dyne. By Coulomb's law $F = \frac{q \times q}{L^2}$.

The unit of current (i) is the current in which the unit of quantity passes in a second.

Unit difference of potential (v) exists between two points when the expenditure of an erg of work is required to bring a unit of + electricity from one point to the other against the electric forces.

A conductor has unit capacity (c) when unit charge raises it to unit potential (*e.g.* an isolated sphere of 1 cm. radius has unit capacity).

The surface density of a conductor at any point is measured by the number of units of electricity, supposed to be uniformly distributed, per square centimetre of its surface.

The resistance of a conductor (r) is measured by the difference of potential at its extremities divided by the current produced in it thereby. The resistance of a conductor is also measured by the time required for the passage of a unit of electricity through it, when unit difference of potential is maintained between its ends.

The specific inductive capacity (k) of a dielectric is measured by the ratio of the capacity of a condenser made of it to that of an air condenser of equal size.

		Dimensions.
Quantity	q = (force × distance^2)$^{\frac{1}{2}}$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}$
Current	i = quantity ÷ time	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}$
Potential	v = work ÷ quantity	$L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$
Resistance	r = potential ÷ current	$L^{-1}T$
Capacity	c = quantity ÷ potential	L'
Sp. ind. capacity	k = capacity ÷ another capacity	A number

(53) Electromagnetic Units.

The C.G.S. unit of current (I) is that current which when passed through a circuit a centimetre long bent into the arc of a circle one centimetre in radius (subtending a radian at the centre) produces a magnetic field of unit-intensity at the centre.

The C.G.S. unit of quantity (Q) is the quantity of electricity which when passed through a circuit in a second produces a unit-current.

The C.G.S. unit of electromotive force (E) or potential exists between two points when one erg of work is expended in bringing a

+ unit of electricity from one point to the other against the electromotive force.

The C.G.S. unit of capacity (C) is the capacity of a condenser which when charged with one C.G.S. unit of quantity is raised to unit potential.

The C.G.S. unit of resistance is the resistance of a conductor such that unit difference of potential between its two extremities causes a unit-current to flow through it.

		Dimensions.
Current	I = intensity of field × length	$L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$
Quantity	Q = current × time	$L^{\frac{1}{2}}M^{\frac{1}{2}}$
Potential / Electromotive force	E = work ÷ quantity	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}$
Resistance	R = electromotive force ÷ current	$L^{1}T^{-1}$
Capacity	C = quantity ÷ potential	$L^{-1}T^{2}$

(54) Ratio of the Electrostatic and Electromagnetic Units.

If the dimensions of the electrostatic units be divided by those of the electromagnetic units, the ratio is found to be expressed by a velocity, that is to say by a length divided by a time, by the reciprocal, by the square, or by the square of the reciprocal of this velocity.

Unit.	Electrostatic.	Electromagnetic.	Ratio.
Quantity	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}$	$L^{\frac{1}{2}}M^{\frac{1}{2}}$	$L^{1}T^{-1} = \omega$.
Potential	$L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}$	$L^{-1}T = \frac{1}{\omega}$.
Capacity	L	$L^{-1}T^{2}$	$L^{2}T^{-2} = \omega^{2}$.
Resistance	$L^{-1}T$	LT^{-1}	$L^{-2}T^{2} = \frac{1}{\omega^{2}}$.

This velocity $\frac{L}{T} = \omega$ is found to be $2{\cdot}9857 \times 10^{10}$ cms. per second, which is nearly equal to the velocity of light, and about 30 times the velocity representing the ohm (see next page).

(55) Relations between the Units in each System.

For Electrostatics :—

force $= \frac{q \times q}{L^{2}}$ which gives q if the unit of force and the distance between the quantities of electricity be given ;

$q = it$ which gives i if the unit of time be given;
energy $= q \times v$ which gives v if the unit of energy be given;
$i = \frac{v}{r}$ which gives r;
$q = vc$ which gives c.

For Electromagnetics :—

$I = H \times \frac{a \tan \alpha}{2\pi}$ which gives I if the intensity of the magnetic field (H) and length of the radius (a) of the circular current and its angle (α) at the centre be given;
$Q = It$ which gives Q, if the unit of time be given;
energy $= Q \times E$ which gives E if the unit of energy be given;
$I = \frac{E}{R}$ which gives R;
$Q = EC$ which gives C.

(56) Practical Units.

Since the C.G.S. electromagnetic units are found to be inconveniently large or small, multiples and submultiples of them are used in practical work.

The practical unit of current, called the AMPÈRE, is $\frac{1}{10}$ of the C.G.S. unit, and is the current produced by the electromotive force of a volt acting through an ohm.

The COULOMB is the quantity of electricity which flows per second in a current of one ampère; it is $\frac{1}{10}$ of the C.G.S. unit of quantity.

The FARAD is the capacity of a condenser which when charged with one coulomb has a potential of one volt. It is 10^{-9} C.G.S. unit of capacity. In practice the microfarad (10^{-15} C.G.S. unit of capacity) is generally used.

The VOLT is the electromotive force required to produce a current of one ampère in a circuit the resistance of which is one ohm. It is 10^8 C.G.S. units of potential. A Daniell cell has an electromotive force of rather more than one volt.

The practical unit of resistance, the OHM, is 10^9 C.G.S. units of resistance. It is nearly represented by a standard platinum-silver wire prepared by a Committee of the British Association and known as the B.A. unit of resistance.

Current	ampère	10^{-1} C.G.S. units.
Quantity	coulomb	10^{-1} ,, ,,
Capacity	farad	10^{-9} ,, ,,
Electromotive force	volt	10^{8} ,, ,,
Resistance	ohm	10^{9} ,, ,,

Another way of regarding the practical units is to consider them as derived from subsidiary units of length, mass, and time. The unit of length (λ) is taken as a quarter of the terrestrial meridian or about 10^9 cms. The unit of mass (μ) is taken as $\frac{1}{10^{11}}$ gram or 10^{-11} of the C.G.S. unit of mass. The unit of time τ is still taken as the second.

Hence the corresponding practical unit of force would be $\lambda\mu\tau^2$ dynes or $\frac{1}{100}$ dyne, and the practical unit of work would be $\lambda^2\mu\tau^{-2}$ ergs or 10^7 ergs.

(57) Practical Standards of Resistance.

By Ohm's Law the current is equal to the electromotive force maintaining it divided by all the resistance in the circuit

$$I = \frac{E}{R}.$$

Of these three quantities the easiest to measure is the resistance, and hence on the standard of resistance all the other practical units depend.

The ohm is defined to be equal to 10^9 C.G.S. units, or an earth-quadrant (10^9 cms.) per second; but the B.A. unit prepared to represent the ohm (and by some writers called the ohm) is only $\cdot 9868 \times 10^9$ C.G.S. units of resistance.

Siemens proposed as a unit the resistance of a column of mercury 1 metre long and 1 square mm. in section; it is found to be equivalent to ·9415 C.G.S. units of resistance.

	C.G.S.	Ohm.	B.A. unit.	Siemens.
C.G.S.	1	1×10^{-9}	$1{\cdot}0134 \times 10^{-9}$	$1{\cdot}0621 \times 10^{-9}$
Ohm.	1×10^9	1	1·0134	1·0621
B.A. unit.	$\cdot 9868 \times 10^9$	·9868	1	1·0481
Siemens.	$\cdot 9415 \times 10^9$	·9415	·9541	1

Older determinations of the value of the B.A. unit.

1 B.A. unit	$= 0{\cdot}9797 \times 10^9 \frac{\text{cm.}}{\text{sec.}}$		Lorenz 1873
	$= 0{\cdot}9912$	,,	Rowland 1876
	$= 1{\cdot}002$	,,	H. F. Weber 1877
	$= 0{\cdot}9893$	,,	Lord Rayleigh 1881
	$= 0{\cdot}9865$	,,	,, 1882
	$= 0{\cdot}9868$	,,	,, 1883
	$= 0{\cdot}9866$	,,	Glazebrook 1882
	$= 0{\cdot}99$	,,	Kohlrausch 1870 corr. 1882.

(58) The Heating Effects of Currents.

According to Joule's law :—the number of calories (gram-degrees) of heat developed in a circuit is equal to the square of the current multiplied by the time and by the resistance of the circuit, and divided by the mechanical equivalent of the unit of heat, all in C.G.S. units.

$$H = \frac{I^2Rt}{J} \text{ (where } J = 4{\cdot}2 \times 10^7 \text{ ergs).}$$

But if I be expressed in ampères and R in ohms, this value must be multiplied by $10^{-2} \times 10^9$ or 10^7.

Hence a current of one ampère in working through one volt develops in the circuit an amount of energy called a JOULE, the heating effect of which is equivalent to 0·2406 calorie.

It is frequently convenient to express the rate at which a current of one ampère when acting through one volt does work by means of the "WATT."

A WATT then is the rate at which work is done by a current of one ampère working through one volt; it is equivalent to 10 meg-ergs or $\frac{1}{746}$ (= ·00134) horse power or ·7373 foot-pound per second; or to $\frac{1}{736}$ (= ·00136) of a cheval-vapeur or ·109 kilogram-metre per second.

(59) Electrolysis. (*Cf.* 80.)

The amount of a radicle (ion) liberated by a current is proportional to the strength of the current; and the mass of it in grams is equal to the product of the strength of the current in ampères, its duration in seconds, the chemical *equivalent* of the radicle set free, and lastly, of the mass of hydrogen set free by one coulomb of electricity.

According to F. Kohlrausch a coulomb of electricity sets free ·0011363 gm. of silver, which is equivalent to $\frac{{\cdot}0011363}{107{\cdot}66} =$ 0·00001055 gm. of hydrogen.

Mascart finds that a coulomb of electricity sets free 0·000010415 gm. of hydrogen.

According to Gray a coulomb of electricity deposits ·000331 gm. of copper, which is equivalent to $\frac{{\cdot}000331}{31{\cdot}59} =$ ·000010478 gm. of hydrogen.

Hence 1 coulomb of electricity sets free very nearly ·0000105 gm. of hydrogen; ·0000105 × 108, or ·001134 gm. silver; ·0000105 $\times \frac{16}{2}$, or ·000084 gm. oxygen; ·0000105 $\times \frac{98}{2}$, or ·0005145 gm. hydrogen sulphate.

(60) Specific Inductive Capacities.

Air	1
Vacuum	0·9994
Hydrogen	0·9997
Carbon dioxide	1·0008
Ethene	1·0007
Sulphur dioxide	1·0037
Benzene	2·199
Carbon disulphide	1·81
Petroleum	2·07—2·03
Turpentine	2·16
Ebonite	2·284
Glass	3·258—1·9
India rubber	2·8—2·22
Gutta percha	4·2—2·462
Chatterton's compound	2·5474
Hooper's composition	3·1
Smith's gutta percha	3·59—3·4
Mica	5
Paraffin (solid)	1·9936 1·96
Resin	1·77
Shellac	2·74—1·95
Sulphur	2·58—1·93
Tar	1·8
Yellow wax	1·86

(61) Contact Differences of Potential in Volts.

In air at about 18° C.

	Carbon.	Copper.	Iron.	Lead.	Platinum.	Tin.	Zinc.	Amal. zinc.	Brass.
Carbon	0	·37	·485	·858	·113	·795	1·096	1·208	·414
Copper	– ·37	0	·146	·542	– ·238	·456	·75	·894	·087
Iron	– ·485	– ·146	0	·401	– ·369	·313	·6	·744	– ·064
Lead	– ·858	– ·542	– ·401	0	– ·771	– ·099	·21	·357	– ·472
Platinum	– ·113	·238	·369	·771	0	·69	·981	1·125	·287
Tin	– ·795	– ·456	– ·313	·099	– ·69	0	·281	·463	– ·372
Zinc	– 1·096	– ·75	– ·6	– ·21	– ·981	– ·281	0	·144	– ·679
Amal. zinc	– 1·028	– ·894	– ·744	– ·357	– 1·125	– ·463	– ·144	0	822
Brass	– ·414	– ·087	·064	·472	– ·287	·372	·679	·822	0

(62) Electromotive Force of Constant Batteries in Volts.

Daniell I.	Amalgam zinc	$H_2SO_4 + 4H_2O$	$CuSO_4$	strong	Copper	1·079
Daniell II.		$H_2SO_4 + 12H_2O$	$CuSO_4$		Copper	0·978
Daniell III.		$H_2SO_4 + 12H_2O$	$Cu2NO_3$	solution	Copper	1·000
Bunsen I.		$H_2SO_4 + 12H_2O$	HNO_3		Carbon	1·964
Bunsen II.		$H_2SO_4 + 12H_2O$	HNO_3 (Δ 1·38)		Carbon	1·888
Grove		$H_2SO_4 + 4H_2O$	HNO_3		Platinum	1·956

A constant Daniell element consisting of an amalgamated zinc plate in a saturated solution of zinc sulphate, and a copper plate in a semi-saturated solution of copper sulphate gives an E.M.F. of 1·07 volt.

(63) Electromotive Force of Common Batteries.

	Volts.
Volta (zinc, acid, copper) (Baille)	1·048
Smee (zinc, acid, platinised silver)	0·47—0·65 ?
Maiche (zinc in mercury, acid, salt solution, platinised carbon)	1·25
Daniell (zinc, acid, copper sulphate, copper) (Sir Wm. Thomson)	1·12
Daniell (zinc, acid, copper sulphate, copper) (Latimer Clark)	1·11
Daniell (zinc, acid, copper sulphate, copper) (Baille, Kohlrausch)	1·138
Grove (zinc, acid, hydrogen nitrate, platinum) (L. Clark)	1·97
Grove (zinc, acid, hydrogen nitrate, platinum) (Kohlrausch)	1·942
Bunsen (zinc, acid, hydrogen nitrate, carbon)	1·75—1·964
Latimer Clark (mercury, mercurous sulphate, zinc)	1·457
Leclanché (zinc, ammonium chloride, carbon, manganese dioxide) (Baille)	1·417
De la Rue (zinc not amal., ammonium chloride, silver and silver chloride)	1·03—1·059
Marié-Davy (zinc, acid, carbon and mercuric sulphate)	1·52
,, ,, (zinc, acid, mercurous sulphate, carbon)	1·2
Bichromate cells freshly set up, about	2 ?
Niaudet (zinc, salt-water, bleaching-powder, carbon)	1·65—1·5

Varieties of Grove's Cell (Poggendorff).

Hydrogen sulphate	Δ 1·136,	hydrogen nitrate	fuming.	1·955
,, ,,	Δ 1·136,	,, ,,	Δ 1·33..	1·809
,, ,,	Δ 1·060,	,, ,,	Δ 1·33..	1·73
,, ,,	Δ 1·060,	,, ,,	Δ 1·19..	1·631
Zinc sulphate solution,		,, ,,	Δ 1·33..	1·673
Sodium chloride solution,		,, ,,	Δ 1·33..	1·905

(64) The Specific Resistance of Substances.

The specific resistance of a substance is the resistance between the opposite faces of a cube of it at 0° C. which measures 1 cm. each way.

The conductivity of a substance is the reciprocal of its resistance.

The resistance of a metal at any temperature $t°$ C. may be calculated from its resistance at 0° C. by the formula

$$R_t = R_0(1 + at \pm bt^2) \text{ where}$$

	a		b
For most pure metals	·003 824	+	·000 001 26
,, mercury	·000 748 5	−	·000 000 398
,, German-silver	·000 443 3	+	·000 000 152
,, platinum-silver	·000 31		
,, gold-silver	·000 7	−	·000 000 062

The resistance of a platinum wire at $T°$ on the absolute scale is given by the formula

$$R = R_0\{0·039369\, T^{\frac{1}{2}} + 0·00216407\, T - 0·2413\}.$$

The resistances of commercial metals are usually much higher than those of pure metals.

If the resistance of pure copper at 0° C. be taken as 1, the resistance at any temperature $t°$ C. is

$t°$ C.	R_t	$t°$ C.	R_t	$t°$ C.	R_t
0	1·00000	11	1·04199	21	1·08164
1	1·00381	12	1·04599	22	1·08553
2	1·00756	13	1·04990	23	1·08954
3	1·01135	14	1·05406	24	1·09356
4	1·01515	15	1·05774	25	1·09763
5	1·01896	16	1·06168	26	1·10161
6	1·02280	17	1·06563	27	1·10567
7	1·02663	18	1·06959	28	1·10972
8	1·03048	19	1·07356	29	1·11382
9	1·03435	20	1·07742	30	1·11782
10	1·03822				

(65) Resistances of Pure Metals and Alloys.

Specific resistances of metals at 0° C. in microhms (really B.A. units × 10^{-6}) and conductivity in "micromhos."

	R in ohms × 10^{-6}	°/ₒ variat. for 1° at 20° C.	Conduct. $\frac{1}{R}$
Silver annealed	1·521	·377	·657
Silver, hard drawn, Δ 10·5	1·609	·377	·621
Copper, hard drawn, Δ 8·95	1·642	·388	·609
Gold, hard drawn, Δ 19·27	2·154	·365	·464
Aluminium, annealed	2·946	·365	·339
Zinc, pressed	5·69	·365	·176
Platinum, annealed	9·158	·365	·109
Iron, soft	9·827	·63	·102
Nickel, annealed	12·6	·63	·079
Tin, pressed	13·36	·365	·075
Lead, pressed, Δ 11·391	19·847	·387	·050
Antimony, pressed	35·9	·389	·028
Mercury, liquid, Δ 13·596	96·146	·072	·010
Bismuth, pressed	132·65	·354	·008
Cadmium	6·8		
Calcium	3·6		
Lithium	8·		
Magnesium	3·1		
Potassium	7·2		
Sodium	2·1		
Strontium	22·7		
Thallium	18·3		
Brass	5·8		
Alloy, gold 2 pts. and silver 1 pt. Δ 15·218	10·99	·065	·091
German silver	21·17	·044	·047
Alloy, silver 2 pts. and platinum 1 pt.	24·66	·031	·041

(66) Specific Resistance of Liquids in B.A. Units.

The resistance usually *decreases* rapidly as the temperature rises.

Water at ·75° C. (Ayrton and Perry)	$1·188 \times 10^8$
,, at 4° C. (Ayrton and Perry)	$9·1 \times 10^6$
,, at 11° C. (Ayrton and Perry)	$3·4 \times 10^5$
Dilute hydrogen sulphate at 18° C. (5°/₀ acid Δ 1·033) (Kohlrausch)	4·88
Dilute hydrogen sulphate at 18° C. (20°/₀ acid Δ 1·1414) (Kohlrausch)	1·562
Dilute hydrogen sulphate at 18° C. (30°/₀ acid Δ 1·22) (Kohlrausch)	1·38
Dilute hydrogen sulphate at 18° C. (40°/₀ acid Δ 1·31) (Kohlrausch)	1·5
Hydrogen nitrate at 18° C. Δ 1·32 (F. Kohlrausch)	1·61
,, ,, at 14° C. Δ 1·36 (Blavier)	1·45
,, ,, at 24° C. Δ 1·36 ,,	1·22
Solution of copper sulphate at 16° C. (8°/₀ salt) (Blavier?)	43·7
,, ,, ,, (16°/₀ salt) ,,	30·0
,, ,, ,, (28°/₀ salt) ,,	23·4
,, ,, ,, at 10° C. (saturated) (Ewing)	29·3
Solution of zinc sulphate at 18° C. (25°/₀ salt) (Kohlrausch)	21·1
,, ,, ,, at 14° C. (saturated) (Blavier)	21·5
,, ,, ,, at 24° C. ,, ,,	17·8
Hydrogen chloride (20°/₀ acid Δ 1·1) at 18° C. (Kohlrausch)	1·34
Ammonium chloride (25°/₀ salt Δ 1·07) ,,	2·53
Calcium chloride (25°/₀ salt Δ 1·23) (Kohlrausch)	5·73
Magnesium chloride (20°/₀ salt Δ 1·176) ,,	7·28
Sodium chloride (20°/₀ salt Δ 1·148) ,,	5·2
,, ,, (26·4°/₀ salt Δ 1·2) ,,	4·73
,, ,, solution saturated at 13° C.	5·3
Zinc chloride (30°/₀ salt Δ 1·3) (Long)	11·0

(67) Resistances of Telegraph Cables per Nautical Mile in B.A. Units.

Red Sea cable at 24° C.	7·94
Malta-Alexandria cable at 24° C.	3·94
Persian Gulf cable at 24° C.	6·284
Second Atlantic cable at 24° C.	4·272
A copper wire weighing one kilog. pure at 24° C.	554
An iron wire 4 mm. in diam. weighing 185·5 kilog.	16·7

(68) Specific Resistances of Non-Metals in B.A. Units.

Selenium (crystallised) at 100° C.	6×10^4
Tellurium at 20° C.	0·207
Tellurium at 19·6° C. (Matthiessen)	0·2125
Red phosphorus at 20° C.	132

Graphite at 22° C. (I.) (Matthiessen)	0·00239
,, ,, (II.) ,,	0·00378
,, ,, (III.) ,,	0·0418
Bunsen's battery coke at 26° C. ,,	0·0672
Gas coke at 25° C. ,,	0·00428
Gas coke at 0° C. (Siemens)	0·00702

N.B.—The resistance of the different varieties of carbon varies very much, it *decreases* about $\frac{1}{2000}$ for every 1° C. through which the sample is heated between 0° C. and 100° C. It also decreases as the pressure increases.

(69) Specific Resistance of Insulators in B.A. Units × 10^6 (megohms nearly).

Ice at − 12·4° C. (Ayrton and Perry)	2240
,, − ·2° C. ,, ,,	284
Glass (soda-lime Δ 2·54) at 20° C. (Foussereau)	$9{\cdot}1 \times 10^7$
,, ,, at 61·2° C. ,,	$7{\cdot}05 \times 12^5$
Glass (crystal Δ 2·94) below 40° C. ,,	∞
,, ,, at 46° C. ,,	$6{\cdot}182 \times 10^9$
,, ,, at 105° C. ,,	$1{\cdot}16 \times 10^7$
Glass (Bohemian), resistance 10 to 15 times that of common glass at the same temperature (Fousserau)	
Glass (white French) at 200° C. (Beetz)	104·3
,, ,, at 350° C. ,,	0·33
,, (green bottle) at 200° C. ,,	31·1
,, ,, at 350° C. ,,	0·128
,, (heavy lead) at 200° C. ,,	323·8
,, ,, at 350° C. ,,	0·846
Glass at 200° C. (from J. Clerk Maxwell)	22·7
,, at 250° C. (from J. Clerk Maxwell)	1·39
,, at 300° C. (from J. Clerk Maxwell)	0·148
,, at 400° C. (from J. Clerk Maxwell)	0·0735
Mica at 20° C. (Ayrton and Perry)	$8{\cdot}4 \times 10^7$
Shellac at 28° C. ,,	9×10^9
Paraffin at 46° C. ,,	$3{\cdot}4 \times 10^{10}$
Ebonite at 46° C. ,,	$2{\cdot}8 \times 10^{10}$
Gutta Percha at 0° C.	7×10^9
,, ,, at 24° C. (J. C. Maxwell)	$3{\cdot}53 \times 10^8$
,, ,, ,, (Latimer Clark)	$4{\cdot}5 \times 10^8$
,, ,, ,, minimum (F. Jenkin)	$2{\cdot}5 \times 10^7$
,, ,, ,, maximum ,,	5×10^8
,, ,, ,, covering of 2nd Atlantic cable	$3{\cdot}42 \times 10^8$
Hooper's composition at 0° C.	$3{\cdot}2 \times 10^{10}$
,, ,, at 24° C. (I.)	$1{\cdot}5 \times 10^{10}$
,, ,, ,, (II.)(Persian Gulf cable)	$7{\cdot}5 \times 10^9$

(70) Table of Thermo-Electric Forces in Microvolts for a difference of 1° C. at about 20° C., Lead being one element.

Bismuth pressed coml.	+97	Antimony pressed	−2·8
Bismuth pressed pure	89	Silver pure hard	−3
Bismuth crystal axial	65	Zinc pressed pure	−3·7
Bismuth cryst. equatorial	45	Copper electrolytic	−3·8
Cobalt	22	Antimony pressed coml.	−6
German silver	11·75	Arsenic	−13·56
Mercury	·418	Iron wire soft	−17·5
Lead	0	Antimony axial	−22·6
Tin	−·1	Antimony equatorial	−26·4
Copper coml.	−·1	Red phosphorus	−29·7
Platinum	−·9	Tellurium	−502
Gold	−1·2	Selenium	−807

(71) Table of Thermo-Electric Values in Microvolts referred to Lead as Zero. [The lower limit of Temperature is − 18° C., the upper limit is 416° C., except for Cadmium 258°, Zinc 373° C., German Silver 175°. A Grove's Cell is Assumed to have the Electromotive Force 1·97 Volts.]

Iron	−17·34 + ·0487t	Zinc	−2·34 − ·024t
Steel	−11·39 + ·0328t	Silver	−2·14 − ·015t
Alloy, platinum 85, nickel 15.	−5·44 + ·011t	Gold	−2·83 − ·0102t
Soft Platinum	+·61 + ·011t	Copper	−1·36 − ·0095t
Hard platinum	−2·6 + ·0075t	Lead	0
Alloy, platinum 95, iridium 5.	−6·22 + ·0055t	Tin	+·43 − ·0055t
Alloy, platinum 85, iridium 15.	−5·77	Aluminium	+·77 − ·0039t
Magnesium	−2·24 + ·0095t	Palladium	+6·25 + ·0359t
German silver	+12·07 + ·0512t	Nickel to 175° C.	+22·04 + ·0512t
Cadmium	−2·66 − ·0429t	Nickel 250° to 310° C.	+84·49 − ·241t
		Nickel from 340° C.	+3·07 + ·0512t

(72) Thermo-Electric Piles.

A bismuth-copper element with one junction at 0° C. and the other at 100° C. gives an E.M.F. of ·005476 volt.

20 elements of Noé's form (German silver and an alloy of zinc and antimony) joined up in series have a resistance of 0·5 B.A. unit, and an E.M.F of 1·25 volt.

6000 Clamond's elements (iron and an alloy of bismuth and antimony) heated by a coke fire, with a resistance of 15·5 B.A. units, give an E.M.F. of 109 volts.

(73) The Morse Alphabet.

A · —
Ä · — · —
B — · · ·
C — · — ·
Ch — — — —
D — · ·
E ·
É · · — · ·
F · · — ·
G — — ·
H · · · ·
I · ·
J · — — —
K — · —
L · — · ·
M — —
N — ·
O — — —
Ö — — — ·
P · — — ·
Q — — · —
R · — ·
S · · ·
T —
U · · —
Ü · · — —
V · · · —
W · — —
X — · · —
Y — · — —
Z — — · ·
Understood
· · · — ·
0 — — — — —
1 · — — — —
2 · · — — —
3 · · · — —
4 · · · · —
5 · · · · ·
6 — · · · ·
7 — — · · ·
8 — — — · ·
9 — — — — ·

Full stop · · · · · ·
Semicolon — · — · — ·
Comma · — · — · —
Repeat (?) · · — — · ·
Hyphen — · · · · —
Apostrophe · — — — — ·

(74) Intensity of Magnetisation.

				C.G.S. units.
Maximum for iron and steel at 12° C. (Rowland)				...1390
,,	nickel	,,	,,	... 494
,,	cobalt	,,	,,	... 800 ?

Magnetic moment of earth (Gauss)............................$8{\cdot}55 \times 10^{25}$

Hence if the earth were uniformly magnetised it would be equivalent to about $\frac{1}{2200}$ of its volume of strongly magnetised steel.

(75) Magnetic Variation at London.

Year.	Declination.	Inclination.	Year.	Declination.	Inclination.
1576		71° 50′	1765	20°	
1580	11° 15′ E.		1773	21° 9′	72° 30′
1600		72°	1780	22° 10′	72° 8′
1612	6° 10′		1785	22° 50′	
1622	6° 12′		1787	23° 19′	
1633	4° 5′		1790	23° 39′	71° 53′
1634	4° 6′E.		1795	23° 58′	
1657	0° 0′		1796	24°	
1660	0° 34′ W.		1799	24° 1′	
1665	1° 22′		1802	24° 6′	70° 35′
1672	2° 30′	73° 47′	1806	24° 9′	
1683	4° 30′		1815	24° 27′	
1692	6°		1818		70° 34′
1700	9° 40′		1820	24° 11′	
1717	10° 42′	75° 10′	1821		70° 3′
1720		74° 42′	1828		69° 47′
1723	14° 17′	73° 30′	1831	24°	
1740	15° 40′		1838		69° 17′
1745	16° 53′		1854		68° 31′
1748	17° 40′		1864	20° 45′	68° 15′
1760	19° 12′				

(76) Magnetic Variation at Greenwich.

Year.	Declination.	Inclination.	Horizontal force in C.G.S. units.
1865	20° 34′ w.	68° 3′	0·1765
1868	20° 13′	67° 57′	·1777
1871	19° 42′	67° 50′	·1785
1874	19° 29′	67° 44′	·1795
1877	18° 57′	67° 40′	·1799
1880	18° 33′	67° 36′	·1804

(77) Magnetic Variation at Kew.

Date.	Declination.	Inclination.	Horizontal force in C.G.S. units.
1858	21° 54′ 8″ w.	68° 22·56′	·1750
1859	47′ 22″	21·41′	·1752
1860	39′ 51″	19·29′	·1755
1861	31′ 36″	17·42′	·1758
1862	23′ 32″	14·89′	·1760
1863	13′ 16″	11·71′	·1762
1864	21° 3′ 35″	9·31′	·1765
1865	20° 59′ 3″	8· 5′	·1766
1866	51′ 10″	5·44′	·1770
1867	40′ 26″	2·62′	·1774
1868	33′ 9″	2·13′	·1775
1869	26′ 24″	68° 0·41′	·1778
1870	18′ 52″	67° 57·98′	·1779
1871	10′ 31″	56·12′	·1781
1872	20° 0′ 31″	53·60′	·1785
1873	19° 57′ 44″	51·19′	·1787
1874	51′ 58″	49·64	·1790
1875	41′ 14″		
1876	31′ 53″		
1877	22′ 22″		
1878	13′ 50″	67° 43′	
1879	19° 6′ 10″	67° 42′	·1796
1880	18° 57′ 59″		
1881	50′ 30″		
1882	18° 44′ 47″		

(78) Magnetic Elements of Towns in Great Britain.

January 1884.	Declination.	Dip.	Total force in C.G.S. units.
Greenwich	18° 10′ W.	67° 30′	·472
Bristol...............	19° 30′ W.	67° 45′	·474
Manchester.........	20° 0′ W.	68° 50′	·478
Dublin...............	22° 15′ W.	69° 30′	·481
Newcastle	19° 55′ W.	69° 45′	·480
Edinburgh	21° 10′ W.	70° 30′	·484
Annual variation..	− 7′	slight decrease.	very little change.

(79) MAGNETIC ELEMENTS OF PLACES ABROAD FOR 1880.

	Declination.	Dip.	Total force in C.G.S. units.
Boothia Felix......	0	90° N.	·65
London	18° 40′ W.	67° 40′ N.	·47
St. Petersburg ..	0° 40′ W.	70° N.	·48
Berlin	11° 30′ W.	64° N.	·48
Paris	16° 45′ W.	66° N.	·47
Paris (1883 Mascart)	16° 33′ W.	65° 17′ N.	·462
Rome	11° 30′ W.	60° N.	·45
New York	7° 57′ W.	72° 12′ N.	·61
Mexico	7° 55′ E.	45 ? N.	·48
Quito	7° 40′ E.	25 ? N.	·35
St. Helena	26° 25′ W.	28° S.	·31
Cape Town	30° 2′ W.	56° 30′ S.	·36
Sydney	9° 30′ E.	62° 45′ S.	·57
Hobarton	8° 49′ E.	71° 5′ S.	·64
Tokio	4° 5′ W.	50° N.	·45

CHEMISTRY.

(80) Atomic and Molecular Weights, Densities, and Solubilities of Elements and Compounds.

N.B.—The names of gaseous compounds are printed in italics, their densities are taken as the number of grams in one normal litre, and their solubilities as the number of ccm. of gas dissolved by 100 grams of water. The atomic weights in brackets are those given by Meyer and Seubert. v.s. means very soluble, dec. means decomposed, comb. means combines with the water.

	Molecular and at. weights.	% of element	Δ	100 grms. water dissolve. 15° C.	100° C.
Aluminium. Al(27·04)	27		2·7	0	
,, oxide Al_2O_3	102	52·9	4	0	
,, chloride Al_2Cl_6	267	20·2		70	v.s.
,, sulphate $Al_23SO_418H_2O$.	666	8·1		100	1130
Alum (potassium) $Al_2K_24SO_4 . 24H_2O$	948	5·7	1·73	12	358
Alum (ammonium) $Al_2(NH_4)_2 4SO_4 . 24H_2O$	906	6·0	1·63	9·4	422
Clay Al_23SiO_3	282	19·15	1·92	0	
Cryolite $Na_6Al_2F_{12}$	420	12·86	3	0	
Felspar $K_2Al_2Si_6O_{10}$	460	11·7	7·3	0	
Ammonia NH_3 (17·01)	17		*·761*	*72700*	
,, chloride NH_4Cl	53·5	33·6	1·5	37	100
,, sulphate $(NH_4)_2SO_4$	132	27·3		70	100
,, nitrate $(NH_4)NO_3$	80	22·5	1·71	200?	100
,, sesquicarbonate $2(NH_4)_2 CO_3.CO_2$	236	30·5		27	100
Antimony Sb (119·6)	120		6·7		
,, trioxide Sb_2O_3	288	83·3	5·6	0	
,, pentoxide Sb_2O_5	320	75		0	
,, trichloride $SbCl_3$	226·5	53	2·67	dec.	
,, sulphide Sb_2S_3	336	71·4	4·6	0	
,, potassio-tartarate $K_2Sb_2O_22C_4H_4O_6 . H_2O$	664	36·1		7	57
Arsenic As(74·9)	75		5·7	0	

	Molecular and at. weights.	% of element.	Δ	100 grms. water dissolve.	
				15° C.	100° C.
ARSENIC—*continued.*					
„ trioxide As_2O_3	198	75·75	3·7	1·2	11
„ pentoxide As_2O_5	230	65·2		150?	
„ trisulphide As_2S_3	246	61	3·5	0	
BARIUM Ba(136·86)	137		3·75		
„ oxide BaO	153	89·5	4·7	dec.	
„ hydrate $BaH_2O_28H_2O$	315	43·5	1·66	5	50
„ dioxide BaO_2	169	81		0	
„ carbonate $BaCO_3$	197	69·5	4·3	0	
„ chloride $BaCl_22H_2O$	244	56·1	3	40	72
„ nitrate $Ba2NO_3$	261	52·5	3·2	8	35
„ sulphate $BaSO_4$	233	58·8	4·5	0	
BISMUTH Bi (207·5)	208		9·8	0	
„ trioxide Bi_2O_3	464	89·7	8·2	0	
BORON B(10·9)	11		2·7 ?	sol.	
„ trioxide B_2O_3	70	31·4	1·8	3	21
„ trichloride BCl_3	117·5	9·4	1·35	dec.	
BROMINE Br (79·76)	80		3	3	3
CADMIUM Cd (111·7)	112		8·67	0	
„ bromide $CdBr_2\ 4H_2O$	344	32·6		v.s.	
„ sulphide Cd S	144	77·8	4·8	0	
„ sulphate $Cd\ SO_4 4H_2O$	280	40			v.s.
CALCIUM Ca (39·91)	40		1·58	95	
„ oxide CaO	56	71·4	3·2	comb.	
„ hydrate CaH_2O_2	74	54·1	2·08	0·18	0·1
„ carbonate $CaCO_3$	100	40	2·7–2·9	0	
„ chloride $CaCl_2\ 6H_2O$	219	18·2	1·6	400	650
„ fluoride CaF_2	78	51·3	3·2	0	
„ phosphate $Ca_3\ 2PO_4$	310	38·7	3·18	0	
„ sulphate $CaSO_4\ 2H_2O$	172	23·26	2·33	·0025	
Bleaching powder $CaOCl_2$	127	31·5		dec ?	
CARBON C (11·97)	12		1·8	0	
„ *monoxide CO*	28	42·86	*1·25*	*2·4*	
„ *dioxide CO_2*	44	27·3	*1·98*	*100*	
„ disulphide CS_2	76	15·8	1·28	0	
Chloroform $CHCl_3$	119·5	10	1·5	0	
Cyanogen C_2N_2	52	46·2	*2·33*	*450*	
Chlorine Cl (35·37)	35·5		*3·18*	*237*	
CHROMIUM Cr (52·45)	52		6·5		

	Molecular and at. weights.	°/₀ of element.	Δ	100 grms. water dissolve. 15° C.	100° C.
CHROMIUM—*continued.*					
,, oxide Cr_2O_3	152	34·2	5·2	0	
,, trioxide CrO_3	100	52	2·68	v.s.	
Chromyl chloride CrO_2Cl_2	155	33·55	1·7	dec.	
Chrome alum $Cr_2K_2\,4SO_4 24H_2O$	998	10·4	1·83	20	50?
,, ironstone Cr_2FeO_4	224	46·4	4·5	0	
COBALT Co (58·6)	59	8·95			
,, chloride $CoCl_2 6H_2O$	238	24·8	1·84	v.s.	
,, nitrate $Co2NO_3\,6H_2O$	291	20·3	1·83	v.s.	
COPPER Cu (63·18)	63·3		8·95	0	
,, oxide CuO	79·3	79·8	6·4	0	
,, chloride $CuCl_2\,2H_2O$	170·3	37·2		60	v.s.
,, hydride Cu_2H_2	128·6	49·2		0	
,, sulphate $CuSO_4\,5H_2O$	249·3	25·4	2·3	39	203
,, sulphide CuS	95·3	66·4	4·2	0	
FLUORINE F (19·06)	19				
GOLD Au (196·2)	196·6		19·3	0	
,, oxide Au_2O_3	441·2	88·9		0	
,, trichloride $AuCl_3$	303·1	64·7		65	v.s.
Hydrogen H	1		*·0896*	*2*	
,, acetate $HC_2H_3O_2$	60	6·67	1·08	∞	
,, *chloride HCl*	36·5	2·7	*1·64*	*46400*	
,, cyanide HCN	27	3·7	·7	∞	
,, fluoride HF	20	5	·988	∞	
,, nitrate HNO_3	63	1·59	1·5	∞	
,, oxide H_2O	18	11·1	·91674		
,, dioxide H_2O_2	34	5·9	1·5	∞	
,, oxalate $H_2C_2O_4\,2H_2O$	126	4·8	1·64	11·5	∞
,, metaphosphate HPO_3	80	1·25		∞	
,, orthophosphate H_3PO_4	98	3·1	1·9	∞	
,, sulphate H_2SO_4	98	2	1·85	∞	
,, *sulphide H_2S*	34	5·9	*1·52*	*323*	
IODINE I (126·54)	127		5	·02?	
IRON Fe (55·88)	56		7·76	0	
,, oxide Fe_2O_3	160	70	5·25	0	
,, oxide (black) Fe_3O_4	232	72·4	5·4	0	
,, carbonate $FeCO_3$	116	48·3	3·85	0	
,, chloride Fe_2Cl_6	325	34·45		v.s.	v.s.
,, sulphate $FeSO_4\,7H_2O$	278	20·15	1·97	70	333

	Molecular and at. weights.	% of element.	Δ	100 grms. water dissolve. 15° C.	100° C.
IRON—*continued.*					
,, sulphide FeS	88	63·6	4·8	0	
LEAD Pb (206·39)	207		11·4	0	
,, oxide PbO	223	92·8	9·3	slight	
,, oxide (red) Pb_3O_4	685	90·7	9·1?	0	
,, dioxide PbO_2	239	86·6	9·5	0	
,, acetate $Pb2C_2H_3O_2\ 3H_2O$	379	54·6	2·54	46	71
,, carbonate $PbCO_3$	267	77·5	6·46	0	
,, chloride $PbCl_2$	278	74·48	5·8	0·6	5
,, chromate $PbCrO_4$	323	64·1	5·65	0	
,, nitrate $Pb2NO_3$	331	62·55	4·6	50	140
,, sulphate $PbSO_4$	303	68·3	6·4	0	
,, sulphide PbS	239	86·6	7·58	0	
LITHIUM Li (7·01)	7		·59	dec.	
MAGNESIUM Mg (23·94)	24		1·7	0	
,, oxide MgO	40	60	3·2	slight	
,, carbonate $MgCO_3$	84	28·57	3·06	0	
,, chloride $MgCl_2\ 6H_2O$	203	11·8	1·56	150	367
,, sulphate $MgSO_4\ 7H_2O$	246	9·76	1·75	104	500
,, ammonio-phosphate $MgNH_4PO_4\ 6H_2O$	245	9·8		0	
MANGANESE Mn (54·8)	55		8		
,, dioxide MnO_2	87	63·2	4·94	0	
,, chloride $MnCl_2\ 4H_2O$	198	27·8	2·0	150	650
,, sulphate $MnSO_4\ 5H_2O$	241	22·8	2	123	93?
MERCURY Hg (199·8)	200		13·6	0	
,, oxide HgO	216	92·6	11·3	0	
,, chloride Hg_2Cl_2	471	84·9	7·18	0	
,, chloride $HgCl_2$	271	73·8	5·42	6·6	54
,, cyanide HgC_2N_2	252	79·4		12	53
,, sulphate $HgSO_4$	296	67·57	6·47	dec.	
,, sulphide HgS	232	86·2	8·2	0	
NICKEL Ni (58·6)	59		8·57	0	
,, sulphate $NiSO_4 7H_2O$	281	21	1·88	107	
Nitrogen N (14·01)	14		*1·256*	*1·5*	
,, *monoxide* N_2O	44	63·6	*1·97*	*78*	
,, *dioxide* NO	30	46·66	*1·34*	*27·5*	
,, *tetroxide* NO_2	46	30·4	*2·06*	dec.	
Oxygen O (15·96)	16		*1·43*	*3*	

	Molecular and at. weights.	°/o of element.	Δ	100 grms. water dissolve. 15° C.	100° C.
PALLADIUM Pd (106·2)	106		12·1	0	
PHOSPHORUS P (30·96)	31		1·84	0	
„ trioxide P_2O_3	110	56·36		comb.	
„ pentoxide	142	43·66		comb.	
„ trichloride PCl_3	137·5	22·54	1·6	dec.	
„ pentachloride PCl_5	208·5	14·86		dec.	
„ oxychloride $POCl_3$	153·5	20·2	1·7	dec.	
PLATINUM Pt (194·3)	194·9		21·5	0	
„ tetrachloride $PtCl_4$	336·9	57·85		v.s.	
„ potassiochloride PtK_2Cl_6	485·9	40·1	3·59	slight	
„ ammoniochloride Pt $(NH_4)_2Cl_6$	443·9	43·9	3	slight	
POTASSIUM K (39·03)	39		0·88	comb.	
„ hydrate HKO	56	69·6	2·	200	
„ chloride KCl	74·5	52·3	1·99	33	58
„ bromide KBr	119	32·8	2·7	60	101
„ iodide KI	166	23·5	3·06	140	200
„ cyanide KCN	65	60		v.s.	122
„ carbonate K_2CO_3	138	56·5	2	91	154
„ and hydrogen carbonate $KHCO_3$	100	39	2·2	28·6	100
„ chromate K_2CrO_4	194	40·2	2·68	48	82
„ dichromate $K_2Cr_2O_7$	294	26·5	2·6	10	100
„ chlorate $KClO_3$	122·5	31·8	2·3	6	60
„ ferricyanide $K_6Fe_2C_{12}N_{12}$	658	35·6	1·8	40	83
„ ferrocyanide $K_8Fe_2C_{12}N_{12}$ $6H_2O$	884	37	1·83	30	91
„ nitrate KNO_3	101	39	2·07	28	235
„ nitrite KNO_2	85	45·9		v.s.	
„ permanganate $K_2Mn_2O_8$	316	24·7	2·71	6·2	
„ sulphate K_2SO_4	174	44·8	2·7	10	26
„ disulphate $K_2S_2O_7$	254	30·7		34	147
„ hydrogen sulphate $KHSO_4$	136	28·7	2·16	16 ?	
SELENIUM Se (78·87)	79		4·3	0	
SILVER Ag (107·66)	108		10·57	0	
„ oxide Ag_2O	232	93·1	7·14		
„ nitrate $AgNO_3$	170	63·5	4·36	230	1111
„ chloride AgCl	143·5	75·27	5·55	0	

	Molecular and at. weights.	°/₀ of element.	Δ	100 grms. water dissolve. 15° C.	100° C.
SILICON Si (28·0)	28		2·6	0	
,, dioxide SiO_2	60	46·7	2·3	0 ?	
,, tetrachloride $SiCl_4$	170	16·5	1·5	dec.	
,, *tetrafluoride* SiF_4	104	26·9	*4·66*	dec.	
SODIUM Na (22·995)	23		0·97	dec.	
,, hydrate HNaO	40	57·5	2·1	60	210
,, borate $Na_2B_4O_7\ 10H_2O$	382	12·05	1·7	6	200
,, carbonate Na_2CO_3	106	43·4	2·04	16	48
,, carbonate (cryst) $Na_2CO_3\ 10H_2O$	286	16·1	1·45	63	420
,, and hydrogen carbonate $NaHCO_3$	84	27·4	2·2	9	dec.
,, chloride NaCl	58·5	39·32	2·1	35·7	39·6
,, nitrate $NaNO_3$	85	27·06	2·24	85	178
,, phosphate $Na_2HPO_4\ 12H_2O$	358	12·85	1·58	16	∞
,, silicate Na_2SiO_3	122	37·7		slowly	
,, sulphate $Na_2SO_4 10H_2O$	322	14·3	1·5	40	242
,, sulphite $Na_2SO_3 7H_2O$	252	18·55		25	100
,, hydrogen sulphite $NaHSO_3$	104	22·1		v.s.	
,, thiosulphate $Na_2S_2O_3\ 5H_2O$	248	18·55		102	∞
STRONTIUM Sr (87·3)	87·6		2·54	dec.	
,, oxide SrO	103·6	84·55	3·9	dec.	
,, hydrate $SrH_2O_2\ 8H_2O$	265·6	33		2	41·7
,, carbonate $SrCO_3$	147·6	59·3	3·8	0	
,, chloride $SrCl_2\ 6H_2O$	266·6	32·85	1·6	83	170
,, nitrate $Sr\ 2NO_3$	211·6	41·4	2·8	67	106
,, sulphate $SrSO_4$	183·6	47·7	3·9	0	
SULPHUR S (31·98)	32		2·07	0	
,, *dioxide* SO_2	64	50	*2·87*	*4728*	
,, trioxide SO_3	80	40	1·97 ?	dec.	
,, chloride S_2Cl_2	135	47·4	1·68	dec.	
,, sulphuryl chloride SO_2Cl_2	135	23·7	1·7	dec.	
TELLURIUM Te, (127·7, 126·3)	128·3		6·4	0	
TIN Sn (117·35)	118		7·3	0	
,, monoxide SnO	134	88·1	6·1	0	
,, dioxide SnO_2	150	78·66	6·95	0	

	Molecular and at. weights.	°/o of element.	Δ	100 grms. water dissolve. 15° C	100° C.
TIN—*continued.*					
,, dichloride $SnCl_2$ $2H_2O$ ..	225	52·45	2·76	270	∞
,, tetrachloride $SnCl_4$	260	45·4	2·36	sol.	
ZINC Zn (64·88)	65		7·2	0	
,, oxide ZnO..................	81	80·4	5·6	0	
,, carbonate $ZnCO_3$	125	52	4·4	0 ?	
,, chloride $ZnCl_2$	136	47·8	2·75	360	v.s.
,, sulphate $ZnSO_4$ $7H_2O$ ...	287	22·6	2	135	654
,, sulphide ZnS	97	67·1	4·1	0	

(81) ATOMIC WEIGHTS OF THE RARE METALS. (MEYER AND SEUBERT.)

Beryllium	Be	9·08	Rubidium.............	Rb	85·2
Cæsium................	Cs	132·7	Ruthenium	Ru	103·5
Cerium	Ce	141·2	Samarium	Sa	120·5 ?
Decipium	Dc	159 ?	Scandium	Sc	43·97
Didymium.............	Di	145	Tantalum	Ta	182
Erbium................	E	166	Terbium...............	Tb	113 ?
Gallium	Ga	69·9	Thallium..............	Tl	203·7
Indium.................	In	113·4	Thorium	Th	231·96
Iridium	Ir	192·5	Thulium	Tm	170·7
Lanthanum...........	La	138·5	Titanium..............	Ti	50·25
Molybdenum..........	Mo	95·9	Tungsten..............	W	183·6
Mosandrium...........	Ms	139·5 ?	Uranium	U	239·8
Niobium (Cb.)........	Nb	93·7	Vanadium	V	51·1
Norwegium...........	Ng	146 ?	Ytterbium	Yb	172·6
Osmium	Os	195	Yttrium	Y	89·9
Rhodium..............	Rh	104·1	Zirconium	Zr	90·4

(82) Factors for Gravimetric Analysis.

Logarithms of the ratios of the molecular and atomic weights of substances required to those of substances weighed.

Weighed.	Required.	Log.	Weighed.	Required.	Log.
Al_2O_3	Al_2	$\bar{1}\cdot72461$	HgS	Hg	$\bar{1}\cdot93552$
AgBr	Br	$\bar{1}\cdot62897$	KCl	K	$\bar{1}\cdot71983$
AgCl	Ag	$\bar{1}\cdot87663$	K_2SO_4	K_2	$\bar{1}\cdot65218$
	Cl	$\bar{1}\cdot39321$	K_2SiF_6	K_2	$\bar{1}\cdot54918$
	HCl	$\bar{1}\cdot40531$		6F	$\bar{1}\cdot71502$
AgCN	CN	$\bar{1}\cdot28870$		Si	$\bar{1}\cdot10391$
AgI	I	$\bar{1}\cdot73264$	MgO	Mg	$\bar{1}\cdot77815$
As_2S_3	2As	$\bar{1}\cdot78503$	$Mg_2P_2O_7$	2Mg	$\bar{1}\cdot33474$
	3S	$\bar{1}\cdot59152$		$2PO_4$	$\bar{1}\cdot93243$
	$3H_2S$	$\bar{1}\cdot61787$		$2H_3PO_4$	$\bar{1}\cdot94596$
$BaCO_3$	Ba	$\bar{1}\cdot84246$	$MgSO_4$	Mg	$\bar{1}\cdot30081$
	CO_2	$\bar{1}\cdot34854$	Mn_3O_4	3Mn	$\bar{1}\cdot85751$
$BaSO_4$	Ba	$\bar{1}\cdot76952$	MnS	Mn	$\bar{1}\cdot80036$
	S	$\bar{1}\cdot13812$	NaCl	Na	$\bar{1}\cdot59546$
	SO_4	$\bar{1}\cdot61470$	Na_2CO_3	2Na	$\bar{1}\cdot63801$
	H_2SO_4	$\bar{1}\cdot62367$	Na_2SO_4	2Na	$\bar{1}\cdot51096$
$BaSiF_6$	Ba	$\bar{1}\cdot69035$	NiO	Ni	$\bar{1}\cdot89539$
Bi_2O_3	2Bi	$\bar{1}\cdot95258$	PtK_2Cl_6	2K	$\bar{1}\cdot20706$
CO_2	C	$\bar{1}\cdot43573$	Pt	N_2	$\bar{1}\cdot15900$
$CaCO_3$	Ca	$\bar{1}\cdot60212$	$Pt(NH_4)_2Cl_6$	$(NH_3)_2$	$\bar{2}\cdot88578$
	CO_2	$\bar{1}\cdot64430$		N_2	$\bar{2}\cdot80152$
CaF_2	F_2	$\bar{1}\cdot68889$	$PbCrO_4$	Pb	$\bar{1}\cdot80592$
$CaSO_4$	Ca	$\bar{1}\cdot46840$		Cr	$\bar{1}\cdot21098$
CdS	Cd	$\bar{1}\cdot89065$		CrO_3	$\bar{1}\cdot49266$
Co_3O_4	3Co	$\bar{1}\cdot86546$	PbS	Pb	$\bar{1}\cdot93744$
Cr_2O_3	Cr_2	$\bar{1}\cdot83671$	$PbSO_4$	Pb	$\bar{1}\cdot83438$
CuO	Cu	$\bar{1}\cdot90218$	SiO_2	Si	$\bar{1}\cdot66959$
Cu_2S_2	2Cu	$\bar{1}\cdot82213$	Sb_2S_3	2Sb	$\bar{1}\cdot85353$
Fe_2O_3	2Fe	$\bar{1}\cdot84515$	SnO_2	Sn	$\bar{1}\cdot89551$
H_2O	2H	$\bar{1}\cdot04673$	$SrSO_4$	Sr	$\bar{1}\cdot67827$
	O	$\bar{1}\cdot94873$	$(UO)_4P_2O_7$	$2PO_4$	$\bar{1}\cdot19986$
Hg_2Cl_2	2Hg	$\bar{1}\cdot92921$	ZnO	Zn	$\bar{1}\cdot90448$
HgO	Hg	$\bar{1}\cdot96662$	ZnS	Zn	$\bar{1}\cdot82597$

Log. °/₀ of required subst. = log. mass of subst. weighed + tabular log. of required substance + 2 − log. mass of substance taken.

(83) Factors for Volumetric Analysis.

Molecular and atomic weights with their logarithms.

Symbol.	Molec. w.	Log.	Symbol.	Molec. w.	Log.
Ag	107·66	2·03205	$K_2Mn_2O_8$	315·34	2·49878
As_2O_3	197·68	2·29596	$K_2Cr_2O_7$	294·68	2·46935
H_3N	17·01	1·23070	MnO_2	86·72	1·93812
HCl	36·37	1·56074	Na_2CO_3	85·84	1·93369
HNO_3	62·89	1·79858	NaHO	39·955	1·60157
$H_2C_2O_4$	89·78	1·95318	NaCl	58·365	1·76615
H_2SO_4	97·82	1·99043	$Na_2S_2O_3$	157·83	2·19819
I	126·54	2·10223	$SnCl_2$	188·09	2·27437

Logarithms of the ratios of the combining proportions of volumetric reagents and of substances with which they react.

Substance used.	Reacts, &c., with.	Log.	Substance used.	Reacts, &c., with.	Log.
Ag	Cl	$\bar{1}$·51659	$C_2H_2O_4$	Na_2CO_3	$\bar{1}$·98051
	C_2N_2	$\bar{1}$·68362		K_2CO_3	·18642
As_2O_3	4Cl	$\bar{1}$·85474	$K_2Mn_2O_8$	5O avail.	$\bar{1}$·40322
	$3H_2S$	$\bar{1}$·71238		10Fe	·24848
	4I	$\bar{1}$·40833		$5C_2H_2O_4$	·15337
$BaCl_2$	H_2SO_4	$\bar{1}$·67112		$5C_2H_2O_4 10H_2O$	·29953
$2CO_2$	MnO_2	$\bar{1}$·99472		$5K_8Fe_2Cy_{12}$	$\bar{1}$·06693
H_2SO_4	$2NH_3$	$\bar{1}$·54130	$K_2Cr_2O_7$	3O avail.	$\bar{1}$·21080
	$2(NO_3)$	·10222		6Fe	·05606
	2NaHO	$\bar{1}$·91217		2Pb	·14637
	Na_2CO_3	$\bar{1}$·94326	NaCl	Ag	·26590
	2KHO	·05871	$2Na_2S_2O_3$	2 I	$\bar{1}$·90404
	K_2CO_3	·14917		MnO_2	$\bar{1}$·43890
	Na_2	$\bar{1}$·67223		Fe_2	$\bar{1}$·54907
$C_2H_2O_4$	$2NH_3$	$\bar{1}$·57855			

Log. mass subst. required = log. number of ccm. taken + log. mass reagent in 1 ccm. + tabular log.

(84) The "Hardness" of Water.

On Clark's scale each degree of hardness corresponds to one grain of calcium carbonate in a gallon (70,000 grains) of water.

On the scale used by Professor Frankland and in France, one degree of hardness corresponds to one part of calcium carbonate in 100,000 parts of water.

On the scale used in Germany, one degree of hardness corresponds to one part of calcium oxide in 100,000 of water.

Clark.	French.	German.
1	1·43	0·8
0·7	1·	0·56
1·25	1·79	1·

Each part of calcium carbonate in solution occasions a waste of from 8–12 times its weight of the best hard soap.

(85) Multiples of some Atomic and Molecular Weights.

	1	2	3	4	5	6	7	8	9
O	15·96	31·92	47·88	63·84	79·8	95·76	111·72	127·68	143·64
HO	16·96	33·92	50·88	67·84	84·8	101·76	118·72	135·68	152·64
H_2O	17·96	35·92	53·88	71·84	89·8	107·76	125·72	143·68	161·64
Cl	35·37	70·74	106·11	141·48	176·85	212·22	247·59	282·96	318·33
Br	79·76	159·52	239·28	319·04	398·8	478·56	558·32	638·08	717·84
I	126·54	232·08	379·62	506·16	632·7	759·45	885·98	1012·32	1138·86
N	14·01	28·02	42·03	56·04	70·05	84·06	98·07	112·08	126·09
NH_2	16·01	32·02	48·03	64·04	80·05	96·06	112·07	128·08	144·09
NO_2	45·93	91·86	137·79	183·72	229·65	275·58	321·51	367·44	413·37
NO_3	61·89	123·78	185·67	247·56	309·45	371·34	433·23	495·12	557·01
C	11·97	23·94	35·91	47·88	59·85	71·82	83·79	95·76	107·73
CO_2	43·89	87·78	131·67	175·56	219·45	263·34	307·23	351·12	395·01
CN	25·98	51·96	77·94	103·92	129·9	155·88	181·86	207·84	233·82
P	30·96	61·92	92·88	123·84	154·8	185·76	216·72	247·68	278·64
SO_4	95·82	191·64	287·46	382·28	479·1	574·92	670·74	766·56	862·38
SiO_2	59·92	119·84	179·76	237·68	299·6	359·52	419·44	479·36	539·28
Al_2O_3	101·96	203·92	305·88	407·84	509·8	611·76	713·72	815·68	917·64

(86) Comparison of Hydrometer Scales.

If r be the reading of the instrument and Δ the density of the liquid

Baumé (liquids heavier than water). $\Delta = \dfrac{144}{144 - r}$

,, (liquids lighter than water). $\Delta = \dfrac{144}{144 + r}$

Cartier. $\Delta = \dfrac{136{\cdot}8}{126{\cdot}1 + r}$.

Twaddle. $\Delta = \dfrac{\frac{r}{2} + 100}{100}$.

Beck. $\Delta = \dfrac{170}{170 \pm r}$.

Balling. $\Delta = \dfrac{200}{200 \pm r}$.

Brix. $\Delta = \dfrac{400}{400 \pm r}$.

° Baumé and over proof.	Δ of dil. spirit.	Δ corresp. to °Baumé.	° Baumé and over proof.	Δ of dil. spirit.	Δ corresp. to °Baumé.	° Baumé.	Δ corresp. to °Baumé.
0	0·92	1·000	23	·8897	1·185	46	1·456
1	·9189	1·007	24	·8883	1·195	47	1·470
2		1·014	25	·8869	1·205	48	1·485
3	·9163	1·020	26	·8854	1·215	49	1·500
4		1·028	27	·8840	1·225	50	1·515
5	·9137	1·035	28	·8825	1·235	51	1·531
6		1·041	29	·8811	1·245	52	1·546
7		1·049	30	·8797	1·256	53	1·562
8	·91	1·057	31	·8783	1·267	54	1·578
9		1·064	32	·8769	1·278	55	1·596
10	·9075	1·072	33		1·289	56	1·615
11		1·080	34		1·300	57	1·634
12	·9049	1·088	35	·8723	1·312	58	1·653
13		1·096	36		1·324	59	1·671
14		1·104	37		1·337	60	1·690
15	·9008	1·113	38	·8678	1·349	61	1·709
16		1·121	39		1·361	62	1·729
17		1·130	40	·8646	1·375	63	1·750
18	·8966	1·138	41		1·388	64	1·771
19		1·147	42	·8615	1·401	65	1·793
20		1·157	43		1·414	66	1·815
21		1·166	44		1·428	67	1·839
22		1·176	45	·8566	1·442	68	1·864

(87) DENSITY AND COMPOSITION OF ACIDS AT 15° C. (*cf.* 86).

Grams hydrogen sulphate in			Grams hyd. nitrate in			Grams hyd. chloride in		
Δ.	100 gm.	100 ccm.	Δ.	100 gm.	100 ccm.	Δ.	100gm.	100 ccm.
1·842	100	184·2	1·530	99·84	152·75	1·212	42·9	52·0
1·796	86·5	155·4	1·529	99·52	152·2	1·210	42·4	51·3
1·753	81·7	143·2	1·514	95·27	144·2	1·205	41·2	49·6
1·711	78·1	133·6	1·506	93·01	139·1	1·199	39·8	47·7
1·672	74·7	124·8	1·494	89·56	133·8	1·195	39·0	46·6
1·634	71·6	117·0	1·486	87·45	129·9	1·190	37·9	45·0
1·597	68·6	109·5	1·482	86·17	127·7	1·185	36·8	43·6
1·563	65·5	102·4	1·463	80·96	118·4	1·180	35·7	42·1
1·530	62·5	95·6	1·438	74·01	106·4	1·175	34·7	40·8
1·498	59·6	89·3	1·432	72·39	103·7	1·171	33·9	39·7
1·468	56·9	83·5	1·429	71·24	101·8	1·166	33·0	38·5
1·438	54·0	77·7	1·419	69·20	98·2	1·161	32·0	37·2
1·410	51·2	72·2	1·400	65·07	91·1	1·157	31·2	36·1
1·383	48·3	66·8	1·381	61·21	84·5	1·152	30·2	34·8
1·357	45·5	61·7	1·372	59·59	81·8	1·143	28·4	32·5
1·332	43·0	57·3	1·353	56·10	75·9	1·134	26·6	28·8
1·308	40·2	52·6	1·331	52·33	69·6	1·125	24·8	27·9
1·285	37·4	48·1	1·323	50·99	67·5	1·116	23·1	25·8
1·263	34·7	43·8	1·298	47·18	61·2	1·108	21·5	23·8
1·241	32·2	40·0	1·274	43·53	55·5	1·100	19·9	21·9
1·220	29·6	36·1	1·237	37·95	46·9	1·091	18·1	19·7
1·200	27·1	32·5	1·211	33·86	41·0	1·083	16·5	17·9
1·180	24·5	28·9	1·172	28·00	32·8	1·075	15·0	16·1
1·162	22·2	25·8	1·157	25·71	29·8	1·067	13·4	14·3
1·142	19·6	22·4	1·105	17·47	19·3	1·060	12·0	12·7
1·125	17·3	19·5	1·067	11·41	12·2	1·052	10·4	10·6
1·108	15·2	16·8	1·045	7·72	8·1	1·044	8·9	9·3
1·091	13·0	14·2				1·036	7·3	7·6
1·075	10·8	11·6				1·029	5·8	6·0
1·060	8·8	9·3				1·022	4·5	4·6
1·045	6·8	7·1				1·014	2·9	2·9

(88) DENSITY AND COMPOSITION OF SOLUTIONS OF ALKALIES, ALCOHOL, AND SALT (*cf.* 86).

Potassium hydrate in			Sodium hydrate in		
Δ.	100 gm.	100 ccm.	Δ.	100 gm.	100 ccm.
1·790	70	125·30	1·748	70	122·36
1·729	65	112·38	1·695	65	110·18
1·667	60	100·02	1·643	60	98·58
1·604	55	88·22	1·591	55	87·51
1·539	50	76·95	1·540	50	77·00
1·475	45	66·38	1·488	45	66·96
1·412	40	56·44	1·437	40	57·48
1·349	35	47·21	1·384	35	48·44
1·288	30	38·64	1·332	30	39·96
1·230	25	30·75	1·279	25	31·97
1·177	20	23·50	1·225	20	24·50
1·128	15	16·86	1·170	15	17·55
1·083	10	10·77	1·115	10	11·15
1·041	5	5·18	1·059	5	5·29

Ammonia at 14° C. in			Sodium Chloride in		
Δ.	100 gm.	100 ccm.	Δ.	100 gm.	100 ccm.
·8844	36	31·84	1·204	26·4	31·8
·8885	34	30·21	1·192	25	29·8
·8929	32	28·57	1·176	23	27·1
·8976	30	26·93	1·159	21	24·3
·9026	28	25·27	1·143	19	21·7
·9078	26	23·60	1·127	17	19·2
·9133	24	21·92	1·111	15	16·7
·9191	22	20·22	1·096	13	14·3
·9251	20	18·50	1·081	11	11·9
·9314	18	16·77	1·066	9	9·6
·9380	16	14·91	1·051	7	7·4
·9449	14	13·23	1·036	5	5·2
·9520	12	11·42	1·022	3	3·1
·9593	10	9·59	1·007	1	1·0

Alcohol in		
Sp. Gr. at 15° C.	100 gm.	100 ccm.
·7947	100	79·47
·8093	95	76·88
·8232	90	74·09
·8363	85	71·08
·8488	80	67·90
·8610	75	64·58
·8729	70	61·10
·8847	65	57·51
·8963	60	53·78
·9077	55	49·92
·9188	50	45·94
·9200*	49·24	45·30
·9296	45	41·83
·9398	40	37·59
·9493	35	33·23
·9578	30	28·73
·9650	25	24·12
·9718	20	19·44
·9775	15	14·66
·9840	10	9·84
·9912	5	4·96

To obtain °/₀ alcohol by volume multiply the numbers in the last column by 1·2583.

* "proof spirit."

(Water at 15° C. = 1.)

(89) Estimation of Carbon Dioxide in Air.

Half an ounce (14·2 ccm.) of lime-water containing ·0195 gm. of lime gives no precipitate when shaken in a bottle of the following sizes the air in which contains the corresponding percentage by volume of carbon dioxide.

Size of bottle in ounces avoirdupois.	Size of bottle in ccm.	Volume of air in ccm.	Carbon dioxide in the air °/₀ by volume.
20·63	584	570	·03
15·60	443	429	·04
12·58	356	342	·05
10·57	299	285	·06
9·13	259	245	·07
8·05	228	214	·08
7·21	204	190	·09
6·54	185	171	·10
6·00	170	156	·11
5·53	157	143	·12
5·15	146	132	·13
4·82	137	123	·14
4·53	128	114	·15
3·52	100	86	·20
2·92	83	69	·25
2·51	71	57	·30
2·01	57	43	·40
1·71	48	34	·50
1·51	43	29	·60
1·36	39	25	·70
1·25	36	22	·80
1·17	33	19	·90
1·10	31	17	1·00

The air of a room should give no precipitate when a 10½ oz. bottle full is shaken with half an ounce of clear lime-water.

(90) Heat Evolved or Absorbed in Chemical and Physical Actions.

The symbols in the following tables express the atomic weights of the elements taken in grams, and the heat evolved or absorbed (−) is expressed in "large" calories (kilogram-degrees). *Aq* means that an indefinite quantity of water is present, *s* that the substance is solid, *l* liquid, and *g* gaseous.

(91) Allotropic Changes of the Elements (*see* 90).

Oxygen into ozone, $3O_2 = 2O_3$	−29·6
Common into insoluble sulphur S. at 18° C.	0
Amorphous insoluble sulphur into amorphous soluble	0·08
Amorphous soluble sulphur into octohedral S_α	−0·08
Plastic into octohedral sulphur $S_\gamma = S_\alpha$	0·4
Prismatic into octohedral sulphur $S_\beta = S_\alpha$	0·08
Vitreous into metallic selenium Se	1·8
White into red crystallised phosphorus P	19·2
White into red amorphous phosphorus P. at 9° C	20·7
Wood charcoal into diamond C.	3
Amorphous into crystallised silicon Si	8·1
Gold ppd. from bromide into condition of that ppd. fr. chloride Au	3·2

(92) Heat of Solution in Water of 22·3 litres of Gases (*see* 90).

Chlorine Cl_2	3	Hydrogen Nitrate HNO_3	14·4
Bromine Br_2	8·3	Sulphur dioxide SO_2	7·7
Hydrogen Chloride HCl	17·4	,, trioxide SO_3	24·6
,, Bromide HBr	20	Chlorine monoxide Cl_2O	9·4
,, Iodide HI	19·4	Boron trichloride BCl_3	70·3
,, Sulphide H_2S	4·75	Silicon tetrafluoride SiF_4	22·3
Ammonia NH_3	8·8	Boron trifluoride BF_3	24·5
Nitrogen Trioxide N_2O_3	13·8	Carbon dioxide CO_2	5·6
,, pentoxide N_2O_5	29·8	Hydrogen cyanide HCN	6·1

(93) FORMATION OF SOLID SALTS FROM THE SOLID BASIC AND GASEOUS ACID OXIDES (*see* 90).

$SO_3 + BaO$	113·8	$CO_2 + BaO$	56
$SO_3 + Na_2O$	135·2	$CO_2 + SrO$	53·4
$N_2O_5 + Na_2O$	121·8	$CO_2 + CaO$	43·4
$N_2O_5 + BaO$	95·6	$CO_2 + PbO$	21·6
$CO_2 + K_2O$	86·6	$CO_2 + Ag_2O$	19·6
$CO_2 + Na_2O$	75·8		

(94) FORMATION OF A GASEOUS COMPOUND BY THE UNION OF GASEOUS CONSTITUENTS (*see* 90).

Hydrogen chloride $H + Cl$	22
,, bromide $H + Br$	13·5
,, iodide $H + I$	− 0·8
,, sulphide $H_2 + S$	7·2
Steam $H_2 + O$	59
Ammonia $3H + N$	12·2
Nitrous oxide $N_2 + O$	− 20·6
Nitric oxide $N + O$	− 21·6
Nitrogen trioxide $N_2 + O_3$	− 22·2
,, tetroxide $N + O_2$	− 2·6
,, pentoxide $N_2 + O_5$	− 1·2
Hydrogen nitrate $H + N + O_3$	34·4
Chlorine monoxide $Cl_2 + O$	− 15·2
Sulphur chloride $S_2 + Cl_2$	16·2
Sulphur dioxide $S + O_2$	71·6
Sulphur trioxide $S + O_3$	96·4
,, ,, $SO_2 + O$	24·8
Sulphuryl dichloride $SO_2 + Cl_2$	13·2
Carbon dioxide $CO + O$	68·2
Carbonyl dichloride $CO + Cl_2$	18·8
,, sulphide $CO + S$	− 3·6
Hydrogen cyanide $CN + H$	7·8
Benzene $3C_2H_2$	171

Ammonium chloride $NH_3 + HCl$	42·5
,, bromide $NH_3 + HBr$	45·6
,, iodide $NH_3 + HI$	44·2
,, cyanide $NH_3 + HCN$	20·5
,, sulphide $NH_3 + H_2S$	23
,, nitrate $NH_3 + HNO_3$	41·9

N.B.—All these salts are solid.

(95) FORMATION OF SOLID, LIQUID, AND GASEOUS OXIDES FROM SUBSTANCES TAKEN IN THEIR ORDINARY CONDITION AT 15° C. (*see* 90).

Alumina ($Al_2 + 3O + 3H_2O$)s	391·6
Antimony tetroxide ($Sb_2 + 4O$)s	248·6
Arsenic trioxide ($As_2 + 3O$)s	154·6
Barium dioxide ($BaO + O$)s	12·1
Bismuth trioxide ($Bi_2 + 3O$)s	39·6
Boron trioxide ($B_2 + 3O$)s	313·6
Cadmium oxide ($Cd + O + Aq$)s	66·4
Carbon monoxide ($C + O$)g	28·8
Carbon dioxide ($C + O_2$)g	97·6
Chromium trioxide ($Cr_2O_3 + O_3$)s	6·2
Cobaltous oxide ($Co + O + Aq$)s	64
Cuprous oxide ($Cu_2 + O$)s	42
Cupric oxide ($Cu + O$)s	38·4
Auric oxide ($Au_2 + 3O + Aq$)s	−11·2
Iodine pentoxide ($I_2 + 5O$)s	45·6
Ferric oxide ($Fe_2 + 3O + Aq$)s	191·2
Water ($H_2 + O$)l	69
Lead Monoxide ($Pb + O$)s	51
Lime ($Ca + O$)s	132
Calcium hydrate ($Ca + O + H_2O$)s	147
Magnesia ($Mg + O + H_2O$)s	149·8
Mercurous oxide ($Hg_2 + O$)s	42·2
Mercuric oxide ($Hg + O$) *yellow*	31
Phosphorus pentoxide ($P_2 + 5O$)s	363·8
Platinic oxide ($Pt + O_2$)s	15
Potassium hydrate ($K_2 + O + H_2O$)s	139·6
Silver oxide ($Ag_2 + O$)s	7
Silicon dioxide ($Si + O_2$)s	219·2
Sodium hydrate ($2Na + O + H_2O$)s	135·6
Strontium hydrate ($Sr + O + H_2O$)s	148·6
Sulphur trioxide ($S + 3O$)s	103·6
Stannous oxide ($Sn + O + Aq$)s	69·8
Stannic oxide ($Sn + O_2 + Aq$)s	135·8
Zinc oxide ($Zn + O$)s	86·4

(96) FORMATION OF CHLORIDES THE ELEMENTS BEING TAKEN IN THEIR ORDINARY CONDITION AT 15° C. (*see* 90).

Aluminium chloride ($Al_2 + Cl_6$)s	321·6
Arsenic trichloride ($As + Cl_3$)l	69·4

Antimony trichloride $(Sb + Cl_3)s$	86·3
Calcium chloride $(Ca + Cl_2)s$	170·2
Cuprous chloride $(Cu_2 + Cl_2)s$	71·2
Cupric chloride $(Cu + Cl_2)s$	51·6
Auric chloride $(Au + Cl_3)s$	22·8
Hydrogen chloride $(H + Cl)d$	39·3
Ferrous chloride $(Fe + Cl_2)s$	82
Ferric chloride $(Fe_2 + 6Cl)s$	192
Lead chloride $(Pb + Cl_2)s$	85·2
Magnesium chloride $(Mg + Cl_2)s$	151
Manganous chloride $(Mn + Cl_2)s$	112
Mercurous chloride $(Hg_2 + Cl_2)s$	81·8
Mercuric chloride $(Hg + Cl_2)s$	62·8
Phosphorus trichloride $(P + Cl_3)l$	75·8
Phosphorus pentachloride $(P + Cl_5)s$	107·8
Potassium chloride $(K + Cl)s$	105
Silver chloride $(Ag + Cl)s$	29·2
Silicon tetrachloride $(Si + Cl_4)l$	157·6
Sodium chloride $(Na + Cl)s$	97·3
Strontium chloride $(Sr + Cl_2)s$	184·6
Stannous chloride $(Sn + Cl_2)s$	80·4
Stannic chloride $(Sn + Cl_4)l$	129·2
Zinc chloride $(Zn + Cl_2)s$	97·2

(97) Formation of Sulphides from Solid Sulphur (Calc.), those of the Heavy Metals Precipitated, and of the Light Metals Crystallised. To pass to Gaseous Sulphur add 1·3 (*see* **90**).

Aluminium sulphide $(Al_2 + S_3)s$	124·4
Cadmium sulphide $(Cd + S)s$	34
Calcium sulphide $(Ca + S)s$	92
Cobalt sulphide $(Co + S)s$	21·8
Cuprous sulphide $(Cu_2 + S)s$	20·2
Cupric sulphide $(Cu + S)s$	10·2
Ferrous sulphide $(Fe + S)s$	23·8
Lead sulphide $(Pb + S)s$	17·8
Magnesium sulphide $(Mg + S)s$	79·6
Manganese sulphide $(Mn + S)s$	45·2
Mercuric sulphide $(Hg + S)s$	19·8
Nickel sulphide $(Ni + S)s$	19·4
Potassium sulphide $(K_2 + S)s$	102·2
Silver sulphide $(Ag_2 + S)s$	3

Sodium sulphide $(Na_2 + S)s$	88·4
Strontium sulphide $(Sr + S)s$	95·2
Zinc sulphide $(Zn + S)s$	43

(98) Formation of Hydrates from Liquid Water (*see* 90).

Hydrogen nitrate $(HNO_3l + H_2O)$	10·6
,, ,, $(HNO_3l + nH_2O)$	14·4
,, sulphate $(SO_3s + H_2O)s$	21·2
,, ,, $(H_2SO_4 + H_2O)l$	6·2
,, ,, $(H_2SO_4 + nH_2O)l$	17
,, iodate $(I_2O_5s + H_2O)s$	3
,, phosphate $(P_2O_5s + 3H_2O)s$	33·8
,, arsenate $(As_2O_5s + 3H_2O)s$	6·8
,, borate $(B_2O_3 + 3H_2O)s$	16·8
Potassium hydrate $(K_2O + H_2O)s$	42·4
,, ,, $(KHO + nH_2O)l$	12·5
Sodium hydrate $(Na_2O + H_2O)s$	35·6
,, ,, $(NaHO + nH_2O)l$	9·8
Barium hydrate $(BaO + H_2O)s$	17·6
,, dioxide $(BaO_2 + H_2O)s$	2·8
,, hydrate $(BaH_2O_2 + nH_2O)l$	10·2
Strontium hydrate $(SrO + H_2O)s$	17·2
,, ,, $(SrH_2O_2 + 9H_2O)s$	18·2
Calcium hydrate $(CaO + H_2O)s$	15·1
Lead hydrate $(PbO + H_2O)s$	2·4
Potassium sulphate $(K_2SO_4 + H_2O)s$	10
Ammonia $(NH_3g + H_2O)l$	7·6
,, $(NH_3g + nH_2O)l$	8·8
Hydrogen chloride $(HClg + 2H_2O)l$	11·6
,, ,, $(HClg + 6{\cdot}5H_2O)l$	16·5
,, ,, $(HClg + nH_2O)l$	17·4
,, bromide $(HBrg + 2H_2O)l$	14·2
,, ,, $(HBrg + nH_2O)l$	20
,, iodide $(HIg + 3H_2O)l$	15·6
,, ,, $(HIg + nH_2O)l$	19·5

n is any large number of molecules so that the solution is dilute.

(99) Heat of Formation of the Chief Non-Metallic Compounds, the Components being taken in their Ordinary Condition at 15° C. (*see* **90**).

Hydrides.	Gaseous.	Liquid.	Solid.	Dissolved.
Hydrogen chloride ($H + Cl$)	22			39·3
,, bromide ($H + Br$)	9·5			29·5
,, iodide ($H + I$)	- 6·2			13·2
,, oxide ($H_2 + O$)	58·2	69	70·4	
,, dioxide ($H_2O + O$)				-21·6
,, sulphide ($H_2 + S$)	4·6			9·2
,, nitride ($H_3 + N$)	12·2			21
Hydroxylamine ($H_3 + O + N$)				19
Hydrogen phosphide ($H_3 + P$)	11·6			
,, arsenide ($H_3 + As$)	-36·7			
Acetylene (C_2(cryst.) $+ H_2$)	-61			
Ethylene (C_2(cryst.) $+ H_4$)	-15·4			
Marsh gas (C(cryst.) $+ H_4$)	18·5			
Hydrogen silicide ($H_4 + Si$)	32·9			

Oxides and Hydrates.	Gas.	Liq.	Sol.	Dis.
Arsenic trioxide (As_2+O_3)			154·6	147
,, pentoxide (As_2+O_5)			219·4	225·4
Boron trioxide (B_2+O_3)			312·6	319·8
Bromine monoxide (Br_2+O)				−12·4
Hydrogen bromate ($H_2O+Br_2+O_5$)				−49·6
Carbon monoxide (C cryst. + O)	25·8			
,, ,, (C amorp. + O)	28·8			
Carbon dioxide (C cryst. + O_2)	94		100	99·6
,, ,, (C amorph. + O_2)	97		103	102·6
Carbon oxysulphide (C cryst. + O + S)	19·6			
,, ,, (C a. + O + S)	22·6			
,, ,, (CO + S)	6·2			
Carbon disulphide (C cryst. + S_2)	−21·1	−14·4		
,, ,, (C a. + S_2)	−18·1	−11·4		
Chlorine monoxide (Cl_2+O)	−15·2			− 5·8
Hydrogen chlorate ($Cl_2+O_5+H_2O$)				−24
,, perchlorate ($Cl_2+O_7+H_2O$)		−30·8		9·8
Iodine monoxide (I_2+O)				−10·4
,, pentoxide (I_2+O_5)			45·6	43·8
Hydrogen iodate ($I_2+O_5+H_2O$)			48·6	43·8
,, periodate ($I_2+O_7+H_2O$)				27
Nitrogen monoxide (N_2+O)	−20·6	−16·2		
,, dioxide (N_2+O_2)	−43·2			
,, trioxide (N_2+O_3)	−22·2			− 8·4
,, tetroxide (N_2+O_4)	− 5·2	3·4		
,, pentoxide (N_2+O_5)	− 1·2	3·6	11·8	28·6
Hydrogen nitrate ($N_2+O_5+H_2O$)	− 0·2	14·2	15·4	28·6
Nitrogen sulphide (N_2+S_2)			−64·6	
Phosphorus pentoxide (P_2+O_5)			363·8	405·4
Hydrogen phosphate ($P_2+O_5+3H_2O$)		395	400	405·4
,, phosphite ($P_2+O_3+3H_2O$)		244·2	250·2	250
,, hypophosphite ($P_2+O_2+3H_2O$)		70	74·8	74·4
Selenium dioxide ($Se+O_2$)			57·6	56·8
Hydrogen selenate ($Se+O_3+H_2O$)				77·2
Silicon dioxide (Si amorp. + O_2)			219·2	207·4
,, ,, (Si cryst. + O_2)			211·1	
,, sulphide (Si amorp. + S_2)			40	
Sulphur dioxide ($S+O_2$)	69·2			76·8
Sulphur trioxide ($S+O_3$)	91·8		103·6	141

Oxides and Hydrates.	Gas.	Liq.	Sol.	Dis.
Hydrogen chlorosulphate (SO_3+HCl) ...		14·4		
Hydrogen hyposulphite ($S_2+O_2+2H_2O$).				17·6
,, thiosulphate ($S_2+O_2+H_2O$)...				67·2
,, dithionate ($S_2+O_5+H_2O$)......				206·6
,, tetrathionate ($S_4+O_5+H_2O$)..				202·6
,, sulphate (SO_2+O+H_2O).......		54·4		72
,, ,, ($S+O_3+H_2O$).........		124	124·8	141
,, ,, ($S+O_4+H$)...........		193	193·8	210
,, tellurate ($Te+O_3+H_2O$)				107
Chlorides, &c.				
Sulphur dichloride (S_2+Cl_2)................	11	17·6		
Sulphuryl dichloride (SO_2+Cl_2)............	133			
Phosphorus trichloride ($P+Cl_3$)............	68·9	75·8		
,, pentachloride ($P+5Cl$).......			107·8	
,, ,, (PCl_3+Cl_2)....			32	
Phosphoryl chloride ($P+Cl_3+O$)..........		142·4		
,, ,, (PCl_3+O)............		66·6		
Silicon tetrachloride (Si am. $+Cl_4$).........	151·3	157·6		
Carbonyl chloride (C cryst. $+O+Cl_2$)	44·6			
Phosphorus pentabromide ($P+5Br$ at 0° C)			63	
Phosphorus triodide ($P+I_3$ at 0° C).......			10·5	

(100) Heat Evolved in Calories (Gram-Degrees) on Burning 1 Gram of :—

Hydrogen to water at 0° C..................................	34462
,, to steam..	28780
Wood-charcoal to carbon dioxide	8080
,, ,, to carbon monoxide	2400
Graphite (natural)..	7797
Gas-coke...	8047
Coke...	7100 – 6860
Graphite from cast-iron	7762
Diamond	7770
Wood (with 20 °/₀ water)	2750

Wood air-dried	2900
,, dried at 120° C	3600
Coal	8300 – 6400
Anthracite	8000
Air-dried peat.	3600
Petroleum	11400
Turpentine	10662
Methyl-Alcohol	5307
Ethyl-alcohol	7184
Amyl-alcohol	8959
Ethyl-ether	9028
Carbon monoxide	2403
Carbon monoxide and hydrogen (equal volumes)	4198
Methane	13063
Ethene	11858
Coal-gas	10600
Benzene vapour	9915
Glycerin $C_3H_8O_3$	5133
Palmitic acid $C_{16}H_{32}O_2$	9317
Stearic acid $C_{18}H_{36}O_2$	9717

(101) Miscellaneous Data in Chemistry.

Mass of a litre of normal hydrogen in grams (crith)	0·0896
,, ,, cubic foot of normal hydrogen in lbs.	·005592
,, ,, litre of normal air in grams	1·2932
,, ,, cubic foot of normal air in lbs.	·080728
,, 22·32 litres of normal air in grams	28·872
Volume in litres of the molecular weight of a gas in grams	22·32
Volume of 1 lb. of air at 62° F. in cubic feet	13·141
Percentage of oxygen in air by volume	20·99
,, ,, ,, ,, ,, mass	23·19
,, ,, carbon dioxide in air by volume	0·04

PHYSIOGRAPHY.

(102) Geological Formations.

The greatest thickness generally in Britain is given in feet, and a few of the characteristic fossils are mentioned.

PRIMARY OR PALÆOZOIC ROCKS.

1. Archæan or Precambrian.

Laurentian (30,000). *Eozoon Canadense ?*
Huronian (10,000 to 20,000 in Canada).

2. Cambrian containing *Protospongia*, *Annelides*, *Trilobites*, and *Brachiopods*.

Lower (10,000).	Harlech and Longmynd. *Palæopyge Ramsayi.* Menevian. *Theca.*
Upper (6,000).	Lingula flags. *Lingulella Davisii*, *Crustacea.* Tremadoc Slates. *Encrinites*, *A star-fish.*

3. Silurian, Transition or Greywacke containing *fucoid plants*, *graptolites*, *corals*, *Placoid fish*, *Crustaceans.*

Lower (13,500).	Arenig. Llandeilo. Caradoc. Bala. Lower Llandovery.	(By some geologists)
Upper (50,000).	Upper Llandovery. Wenlock. *Coral.* Ludlow. *Onchus ? Palæchinus*, *Pterygotus.*	*Pentamerus.*

4. Devonian and Old Red Sandstone (10,000). *Fish, Insects.*

Devonian.	Lower. *Cryptogams.* Middle. *Goniatites, Bryozoa.* Upper. These beds are probably marine.	Old Red Sandstone.	Lower. *Cephalaspis, Ferns, Lycopods.* Upper. *Ganoid Fish, Dicotyledonous wood.*

5. Carboniferous Series.

Yellow Sandstone. Mountain Limestone.	(6,500) *Crinoids, Corals, Terebratula.*
Millstone grit (5,000).	
Coal measures with Gannister, Shale, &c.	(12,000) *Ferns, Lepidodendron, Cypris, Calamites, Lycopodiaceæ, Labyrinthodonts.*

6. Permian or Dyas (3,500) *last Lepidodendra, Calamaries, and Sigillarioids. Amphibians abundant.*

Magnesian Limestone, &c. Red conglomerates and sandstones.	*Proterosaurus, Branchiosaurus, Lepidotosaurus.*

SECONDARY OR MESOZOIC ROCKS.

1. Triassic (5,200). *Ferns, Equiseta, Conifers, Cycads, Ammonites, Labyrinthodonts.*

Bunter. Muschelkalk. Keuper. Rhætic.	*Rock-salt, Microlestes antiquus—the first mammal, a Crocodile, a Land-lizard.*

2. Jurassic or Oolitic, *Reptiles abundant, Coral, Cycads abundant, Conifers.*

Lower Lias. Middle Lias. Upper Lias.	(1,500) *Ammonites, Belemnites, Nautili. Ichthyosaurus, Plesiosaurus, Megalosaurus, Atlantosaurus, Pterodactyl.*

Lower Oolite (Bathonian 780).	*Gasteropods numerous. Sea-urchins, Araucarites, Teleosaurus, Marsupials, Ramphorhynchus, Ceteosaurus.*
Middle Oolite (Oxfordian 800).	*Gryphæa, Steneosaurus, Archæopteryx.*
Upper Oolite (Portlandian 1,380).	*Terebratula, Lingula, Turtles, Ammonites, and Belemnites abundant.*

3. Cretaceous. *Dicotyledonous Plants, Sponges, Reptiles, Foraminifera, Toothed Birds.*

Neocomian (1,800 Wealden and Lower Greensand). *Insects, Crocodilia, Mammals, Iguanodon, Zamias, Meyeria.*
Gault (a stiff blue sandy or calcareous clay, 200).
Cenomanian, (350 Upper Greensand). *Coniferous trees.*

Turonian (250 without flints). Senonian (850 with flints). Danian (wanting in England).	*Sponges, Corals, Foraminifera* e.g. *Globigerina bulloides, Goniaster, Micraster, Mosasaurus, Several Turtles.*

Ammonites and Belemnites cease.

TERTIARY OR CAINOZOIC ROCKS.

1. Eocene (London, Paris, and Hampshire Basins, 1,900).

Lower Eocene (Thanet, Woolwich, Reading beds, London clay, Lower Bagshot sand). *Sharks, Arctocyon primævus, Lithornis, Halcyornis, Hyracotherium, Palæophis Typhæus, Conifers, Figs, Junipers, Citrons.*

Middle Eocene (Bagshot and Bracklesham beds). *Turtles, Sharks, Marine shells, Palæotherium, Pterodon, Cænopithecus.*

Upper Eocene (Barton clay, Upper Bagshot sand). *Molluscs, Fish, a Crocodile, Anchitherium, Hyopotamus, Opossums, Cynodon, Eohippus, Deinoceras.*

2. Oligocene (Hemstead, Headon, Bovey Tracey beds). *Oaks, Willows, Vines, Anoplotherium, Parroquets, Flamingoes, Ibises, Pelicans, Cranes, Eagles, Grouse.*

3. MIOCENE (wanting in England). *Sequoia, Myrtus, Acacia, Betula, Mastodon, Deinotherium, Rhinoceros, Dricroceras, Machairodus, Hyœnarctos, Anthropoid Apes, Palæocastor.*

4. PLIOCENE (Coralline, Red, Norwich Crag, 180). Salt-beds in Poland. *Many modern trees,* e.g. *walnut, maple, birch, hickory. Hipparion, Elephas meridionalis, Tapirus priscus, Sus antiquus, Hyæna antiqua, Equus plicidens, Felis pardoides, Cervus, Castor.*

5. PLEISTOCENE (Diluvium, Glacial action, Cave deposits). *Many ancient animals,* e.g. *Machairodus latidens, Elephas antiquus, and primigenius, Lagomys spelæus, Cave-bear, Cave-lion, Cave-hyæna, Canadian and Irish Elk and Mammoth are gradually replaced by modern forms,* e.g. *Lion, Grizzly and Polar Bears, Wild Boar, Wolf, Fox, Glutton, Reindeer, Roe-deer, Red-deer, Beaver, Urus, Ibex, Musk-sheep. Man was contemporaneous with most of these animals.*

6. PREHISTORIC AND RECENT PERIOD. Divided into periods by the material chiefly used for implements and weapons :—

(α). Palæolithic age (*rough chipped stone implements*).

(β). Neolithic age (*smooth rubbed stone implements*).

(γ). Bronze age (*copper, and copper tin zinc and lead implements*). (Homer).

(δ). Iron age.

(103) LENGTHS OF RIVERS IN KILOMETRES. (*Cf.* 9.)

Mississippi	7200	Rio de la Plata	4000
Nile	6500?	Volga	3600
Amazons	6200	Danube	2800
Jenissei	5500	Thames	346
Yang-tse-kiang	5200	Severn	322

(104) HEIGHTS AND DEPTHS IN METRES. (*Cf.* 9.)

Mt. Everest (Nepaul)	8840	Ben Nevis	1331
Dapsang (Asia)	8621	Snowdon	1094
Kantchin Djinga	8582	Lake Palte	4114
Aconcagua (Chili)	6834	Lake Titicaca	3808
Chimborazo	6530	Lake Baikal	469
Kilima Ndjaro (Africa)	5705	Great Pyramid	142
Elbrouz (Persia)	5647	RoseBridgeMine(Wigan)	− 745
Popocatapetl	5410	Dead Sea (surface)	− 396
Mt. Brown (N. America)	4876	Caspian Sea (bottom)	− 914
Mt. Blanc	4810	Ocean (mean depth)	− 900?
Oroya Railway, highest	4768	Atlantic (greatest depth)	− 7086
Mauna Loa (Hawaii)	4135	Pacific (greatest depth)	− 8321

(105) VELOCITY AND PRESSURE OF THE WIND.

Desc. No.	Descriptive name.	Miles per hour.	Lbs. per sq. foot, about.
0	Calm	3	·08
1	Light air	8	·6
2	Light breeze	13	1·5
3	Gentle breeze	18	2·9
4	Moderate breeze	23	4·7
5	Fresh breeze	28	6·9
6	Strong breeze	34	10·2
7	Moderate gale	40	14·2
8	Fresh gale	48	20·3
9	Strong gale	56	27·8
10	Whole gale	65	37·5
11	Storm	75	49·9
12	Hurricane	90	71·8

(106) Velocity of the Tide in Miles per Hour (V) in Water x Fathoms Deep.

	V	x	V	x	V
1	8	50	57	100	80
10	25	60	63	200	114
20	36	70	65	400	160
30	44	80	73	1000	250
40	51	90	77	4000	500

(107) Course of the Tide to the English Coasts.

A high tide leaving the Cape of Good Hope about 1 passes up the Atlantic, reaches the Equator at 6, the Tropic of Cancer at 9, the Azores at 12; it stretches from C. Finisterre to Iceland about 3, and is 1° of lat. S.W. of the Land's End about 4. The Northern portion sweeps round the I. of Lewis at 7, and the Orkneys at 8, at 11 it reaches Peterhead and Egersund in Norway, at 12.30 Aberdeen and the Naze, at 2 Edinburgh, at 4 Flambro' Head, at 7 Boston, and at 8.30 Great Yarmouth. A second portion passes up St. George's Channel reaching St. David's Head at 6, the Isle of Man at 10, Belfast and Port Patrick at 11. The Southern portion passes up the English Channel reaching Falmouth and Morlaix at 5, Portland Bill and Cape la Hague at 7, the Isle of Wight and Barfleur at 8, Deal and Calais at 11, Ramsgate and Dunkirk at 12, London Bridge at 2.15, Yarmouth at 3, and the coast of Jutland at 1.

The highest tide is the third tide or some 36 hours after new and full moon.

(108) Time of High Water on the Full and Change of the Moon or Establishments of the Following Ports.

N.B.—The "tide interval" between any two places being always approximately the same, if the time of high tide at any port mentioned be known on any day that at any other port may be calculated.

	h.	m.
Aberdeen	1	
Aberystwith	7	31
Achill-Beg	5	14
Agnes, St., Scilly Isles.	4	30
Alderney	6	46
Antwerp	4	25
Ayr Point, Isle of Man..	11	7
Bantry Bay	3	47
Beachy Head	11	20
Belfast	10	43
Berwick	2	18
Bordeaux	6	50
Boulogne	11	25
Brest	3	47
Brighton	11	15
Bristol	7	13
Calais	11	49
Cantyre (Mull of)	10	35
Cherbourg	7	49
Cowes, West	10	45
Deal	11	15
Dover	11	12
Dublin Bar	11	12
Falmouth	4	57
Flambro' Head	4	30
Flushing	0	54
Gibraltar	2	20
Glasgow Port	0	18
Gravelines	12	0
Gravesend	1	10
Grimsby	5	36
Harwich	0	6
Hastings	10	53
Helgoland	11	33
Holyhead	10	11
Horn Point, Jutland	1	44
Land's End	4	30
Lerwick	10	30
Lewis Island	6	11
Liverpool	11	23
London Bridge	1	58
Milford Haven	5	56
Needles Point	9	46
Newcastle	4	23
Nore Light	0	30
Pentland Firth	11	0
Rathlin Island	7	56
Scarborough	4	11
Shannon Mouth	4	0
Southampton	10	30
Swansea Bay	6	10
Whitby	3	45
Wick	11	22
Wisbeach	7	30
Wranger Oog, Friesland	12	0
Yarmouth Roads	9	15
Youghal	5	14

(109) Latitude and Longitude of Towns (*cf.* 8, 110).

N.B.—O stands for an observatory.

	Latitude.	Longitude.	
		In Angle.	In Time.
			H. M. S.
Adelaide O.	34° 55′ 33·8″ S.	138° 35′ 20″ E.	9 14 21·3 E.
Antipodes Isle	49° 25′ S.	179° 30′ E.	11 58 E.
Athens O.	37° 58′ 20″ N.	23° 43′ 56″ E.	1 34 55·7 E.
Berlin O.	52° 30′ 16·7″ N.	13° 23′ 43″ E.	0 53 34·9 E.
Bonn O.	50° 43′ 45″ N.	7° 5′ 49″ E.	0 28 23·9 E.
Calcutta	22° 34′ 45″ N.	88° 27′ 56″ E.	5 53 52 E.
Cambridge O.	52° 12′ 51·6″ N.	0° 5′ 41″ E.	0 0 22·8 E.
C. of Good Hope O.	33° 56′ 3·5″ S.	18° 28′ 45″ E.	1 13 55 E.
Dublin O.	53° 23′ 13″ N.	6° 20′ 30″ W.	0 25 22 W.
Edinburgh O.	55° 57′ 23·2″ N.	3° 10′ 53″ W.	0 12 43·6 W.
Glasgow O.	55° 52′ 42·8″ N.	4° 17′ 39″ W.	0 17 10·6 W.
Greenwich O.	51° 28′ 38·4″ N.	0° 0′ 0″	0 0 0
Lisbon, Royal O.	38° 42′ 31·3″ N.	9° 11′ 10″ W.	0 36 44·7 W.
Madras O.	13° 4′ 8·1″ N.	80° 14′ 51″ E.	5 20 59·4 E.
Melbourne O.	37° 49′ 53·4″ S.	144° 58′ 42″ E.	9 39 54·8 E.
Moscow O.	55° 45′ 19·8″ N.	37° 34′ 15″ E.	2 30 17 E.
Oxford, Radcliffe O.	51° 45′ 36″ N.	1° 15′ 39″ W.	0 5 2·6 W.
Paris O.	48° 50′ 13″ N.	2° 20′ 14″ E.	0 9 20·9 E.
Pekin	39° 54′ 47″ N.	116° 24′ 45″ E.	7 45 39 E.
Quebec O.	46° 48′ 30″ N.	71° 12′ 15″ W.	4 44 49 W.
Rio de Janeiro O.	22° 54′ 23·8″ S.	43° 10′ 21″ W.	2 52 41·4 W.
Rome O.	41° 53′ 52·2″ N.	12° 28′ 40″ E.	0 49 54·7 E.
San Francisco	37° 48′ 5″ N.	122° 24′ W.	8 9 36 E.
St. Petersburg O.	59° 56′ 29·7″ N.	30° 18′ 22″ E.	2 1 13·5 E.
Santiago de Chile O.	33° 26′ 42″ S.	70° 40′ 36″ W.	4 42 42·4 W.
Sydney O.	33° 51′ 41·1 S.	151° 11′ 49″ E.	10 4 47·3 E.
Vienna, Old O.	48° 12′ 35·5″ N.	16° 22′ 49″ E.	1 5 31·3 E.
Washington Naval O.	38° 53′ 38·8″ N.	77° 3′ 1″ W.	5 8 12·1 W.
Wellington	41° S.	174° 30′ E.	11 38 E.
York	53° 57′ 45″ N.	1° 6′ 4″ W.	0 4 24 W.

(110) DISTANCES AND AREAS ON THE SURFACE OF THE GLOBE.

The areas are the number of millions of square feet in a quadrilateral the sides of which cover 1′ of Longitude by 1′ of Latitude (*cf.* 112).

At° Lat.	Longitude.		Latitude.		Area in 1 000 000 sq. ft.
	Feet to 1′.	Miles to 1°.	Feet to 1′.	Miles to 1°.	
0	6086	69·15	6045	68·69	36·78
10	5994	68·11	6047	68·70	36·24
20	5721	65·01	6053	68·77	34·62
30	5275	59·94	6061	68·88	31·97
40	4669	53·05	6071	69·00	28·35
45	4311	48·99	6076	69·05	26·19
50	3920	44·54	6081	69·10	23·84
60	3051	34·66	6091	69·21	18·58
70	2088	23·73	6100	69·32	12·74
80	1060	12·05	6105	69·38	6·47
90	0	0	6107	69·39	0

(111) Distances and Areas on Mercator's and Galle's Projections.

On Mercator's projection 1′ of Longitude is everywhere 8086 feet, and on Galle's projection 1′ of Longitude is everywhere 4311 feet, In each case the Latitude is altered in proportion to the change in the Longitude. The areas are the number of millions of square feet in a quadrilateral the sides of which cover 1′ of Longitude by 1′ of Latitude. Ratio of area on the map to the true area.

At° Lat.	Mercator.			Galle.		
	Feet in 1′ Lat.	Area.	Ratio.	Feet in 1′ Lat.	Area.	Ratio.
0	6045	36·78	1	4283	18·46	·502
10	6138	37·36	1·03	4349	18·75	·52
20	6438	39·17	1·13	4560	19·66	·57
30	6993	42·56	1·33	4955	21·36	·67
40	7913	48·17	1·70	5606	24·17	·85
45	8575	52·19	1·99	6076	26·19	1·00
50	9440	57·45	2·41	6688	28·83	1·21
60	12150	73·95	3·98	8609	37·11	1·99
70	17780	108·20	8·49	12590	54·30	4·26
80	35060	213·37	32·98	24829	107·04	16·54
90	∞	∞	∞	∞	∞	∞

(112) Dimensions of the Earth (*cf.* 9).

If the earth be considered as an ellipsoid, the longer equatorial diameter (2*a*) passes through the meridian 15° 34′ E., and the shorter equatorial diameter (2*b*) passes through the meridian 105° 34′ E.

Longer equatorial semi-diameter (*a*)	20 926 350 ft.	6 378 294 m.
Shorter equatorial semi-diameter (*b*)	20 919 972 ft.	6 376 350·4 m.
Polar semi-diameter (*c*)	20 853 429 ft.	6 356 068·1 m.

The length of the quadrant passing through Paris is 10 001 472·5 m. and that of the minimum quadrant (105° 34′ E.) is 10 000 024·5 m. A geographical mile or knot, which is the distance on the equator subtended by 1′ of longitude, is 6087 feet, 1·153 statute mile, or 1855·3 metres.

If the earth be considered as an oblate spheroid :—

Equatorial semi-diameter (a)

20 926 062 ft. | 3963·3 miles. | 6 378 206·4 m.

Polar semi-diameter (c)

20 855 121 ft. | 3949·79 miles | 6 356 503·8 m.

$a - c = 13{\cdot}51$ miles. $\qquad \dfrac{a-c}{a} = \dfrac{1}{295} = 0{\cdot}00339$

If the earth be considered as a sphere the radius is 3959 miles or 6 371 300 metres, and the number of miles subtending 1° of longitude at any latitude is 69·09 × cosine latitude.

Surface of the earth 197 000 000 ? square miles (about ¼ is land and ¾ ocean).

Volume of the earth 260 000 000 000 ? cubic miles.

Density of the earth 5·67 ? times that of water.

Mass of the earth $6{\cdot}04 \times 10^{21}$.? tons.

(113) Mean Density of the Earth.

From experiments with the

Plumb-line at Schiehallien (Maskelyne and Playfair)...	4·713
,, at Arthur's Seat (James)........................	5·316
Pendulum at Mont Cenis (Carlini and Giulio)............	4·95
,, at Harton coal-pit (Airy).........................	6·565
Torsion-balance (Cavendish 1798)...........................	5·48
,, ,, (Reich 1838)..	5·49
,, ,, (Baily 1843)..	5·66
,, ,, (Cornu and Baille 1872)	5·5 — 5·56

(114) The Moon.

The horizontal parallax of the moon is 57′ 2·7″; her greatest distance from the earth is 259,600 miles, and her least distance 221,000 miles. The eccentricity of her orbit is 0·055.

The mean distance of the moon is about 60·3 radii of the earth, or 240,000 miles. The inclination of the plane of the moon's orbit to the ecliptic is *about* 5° 8′ 42″.

The moon is very nearly spherical, with a radius of 1,080 miles; her volume is $5·2765 \times 10^9$ cubic miles, or about $\frac{1}{50}$ of the volume of the earth; her mass is about $\frac{1}{80}$ of the mass of the earth, hence the acceleration of gravity at her surface would be about 5·4 feet per second per second. The density of the moon is about 3·5, or rather more than half that of the earth.

(115) The Calendar (*cf.* 6).

The tropical year is 365 days 5 hours 48 minutes 46 seconds, or 365·2422 mean solar days.

The solar cycle is 28 Julian years, after which period the same day of the week falls on the same day of the solar month (1884 is the 17th).

The Sothic period was 1460 (more nearly 1500) years.

The cycle of the Roman Indiction was 15 years (1884 is the 12th).

A sidereal month or complete circuit of the moon in the heavens is 27·3217 days.

A lunar month (lunation) is 29·5306 days.

An anomalistic month (perigee to perigee) is 27·5446 days.

A tropical month (vernal equinox to vernal equinox) is 27·3216 days.

A nodical month (node to node of the same kind) is 27·2122 days.

The Saros, or cycle of the conjunction of the sun and moon in nearly the same place on the ecliptic (223 lunations), is 6585·3212 days, or 18 years and 10 or 11 days.

The Lunar or Metonic cycle after which new moons fall on the same days of the year (235 lunations) is 6939·6876 days or nearly 19 years. In 1884 the Golden Number is IV.

The Julian period, after which the solar and lunar cycles and the Roman Indiction recur, is (28 × 19 × 15) 7980 years, of which the first was 4713 B.C. (1884 is the 6597th).

YEARS OF THE JULIAN PERIOD.

Year 1 of the	Jewish Era (Oct. 7th)	953
,, ,,	1st Olympiad (July 1st)	3938
,, ,,	Foundation of Rome	3961
,, ,,	Egyptian Era (Feb. 26th)	3967
,, ,,	Christian Era	4714
,, ,,	Hegira (July 16th)	5335
,, ,,	French Republic (Sept. 22nd)	6505

January 1st, 1884, is the 2,409,177th day of the Julian Period.

(116) ELEMENTS OF THE SOLAR SYSTEM.

The Constant of Aberration is 20″·4451.

The mean obliquity of the Ecliptic is 23° 27′ 15″·65 on Jan. 1st, 1884, and the mean annual diminution is 0″·476.

The Equatorial Horizontal Parallax of the Sun at the Earth's mean distance is 8″·848.

North declination of α Ursæ Minoris (Pole Star) for Jan. 1st, 1884, is 88° 41′ 45″·5 with an increase of nearly 16″·5 per annum. Hence the Pole star is about 1° 18′ from the celestial pole.

(*See over.*)

(116) ELEMENTS OF THE SOLAR SYSTEM—*continued.*

	Distance from Sun.		Periodic Time in Days.	Periodic Time in Years.	Inclination of Orbit.	Equat. semi-diameters at mean distance of Earth from Sun.
	Earth = 1.	1 000 000 miles.				
Sun						16′ 1″·82
Mercury	0·3871	35·75	87·97	0·24	7° 0′ 8″	3″·34
Venus	0·7233	66·75	224·70	0·61	3° 23′ 35″	8″·305
Earth	1·0000	92·33	365·26	1·00	0° 0′ 0″	
Mars	1·5237	141	686·98	1·88	1° 51′ 2″	5″·55
Jupiter	5·2028	480	4332·6	11·86	1° 18′ 41″	98″·19
Saturn	9·5389	881	10759·2	29·46	2° 29′ 40″	83″·31
Uranus	19·1834	1771	30688·4	84·02	0° 46′ 20″	34″·28
Neptune	30·0544	2775	60181·1	164·78	1° 47′ 2″	

(116) Elements of the Solar System—*continued.*

	Mean diameter in miles.	Volume.	Mass.	Density.	Gravity at Equator.	Time of Rotation.
Sun	860000	1 280 000	10000000	0·25	27·7	25 days ?
Mercury	2992	0·05	2	1·21	·4	24 hours.
Venus	7660	0·97	23·5	0·85	·8	23h. 21m.
Earth...........................	7918	1·00	30·6	1·00	1·0	23h. 56m.
Mars	4211	0·15	3·4	0·73	·4	24h. 37m.
Jupiter	86000	1279	9542·	0·24	2·6	9h. 55m.
Saturn	70500	719	2856·	0·13	1·2	10h. 14m.
Uranus	31700	57·8	442·5	0·23	·9	
Neptune	34500	55	516·	{ 0·20 { 0·41	{ ·9 { 1·56	

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